35

2

JOURNAL

OF THE

Association of Engineering Societies.

ST. LOUIS. MINNEAPOLIS. PACIFIC COAST. LOUISIANA.
CLEVELAND. ST. PAUL. DETROIT. TOLEDO.
BOSTON. MONTANA. BUFFALO.

CONTENTS AND INDEX.

VOLUME XXXVI.

January to June, 1906.

PUBLISHED MONTHLY BY

FRED. BROOKS, SECRETARY OF THE BOARD OF MANAGERS OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

31 MILK STREET, BOSTON.

The Fort Hill Press
SAMUEL USHER
176 TO 184 HIGH STREET
BOSTON, MASS.

CONTENTS.

VOL. XXXVI, January–June, 1906.

For alphabetical index, see page v.

INDEX.

VOL. XXXVI, January–June, 1906.

ABBREVIATIONS. — P = Paper; D = Discussion; I = Illustrated. Names of authors of papers, etc., are printed in *italics*.

Editors reprinting articles from this JOURNAL are requested to credit the author, the JOURNAL OF THE ASSOCIATION, and the Society before which such articles were read.

ASSOCIATION
OF
ENGINEERING SOCIETIES.

Organized 1881.

VOL. XXXVI. JANUARY, 1906. No. 1

AN EFFICIENT MODERN STEAM PLANT IN FLOUR-MILL SERVICE.

BY WILLIAM H. BRYAN, MEMBER OF THE ENGINEERS' CLUB OF ST. LOUIS.

[Read before the Club, September 20, 1905.]

THE object of the investigation herein reported upon was to ascertain the efficiency of a new power plant, considering the boiler and engine independently, and the mill as a whole, comparing the coal burned with the work done and flour made. A further object was to compare these results with the efficiency of the same mill before the new machinery was put in; also to determine the adjustment of all parts, whether the engine was doing its proper share of the work, and what parts, if any, were in need of further adjustment. Also what units were less economical than others, and what further improvements or adjustments, if any, could readily be made.

THE MILL.

This plant is owned by the Wolff Milling Company, and is situated at New Haven, Mo., a town of about 1 500 inhabitants, 67 miles west of St. Louis on the Missouri Pacific Railroad, located on the south bank of the Missouri River, which stream forms the northern boundary of Franklin County.

The mill is what is called a 400-bbl. mill, that being its nominal output of flour in 24 hr. It is customary, however, to run the mill only 12 hr. per day, but its rating per hr. can readily be exceeded 10 per cent. or even more, under favorable conditions. In addition, there is the usual grain elevator, stones for grinding corn meal, and machinery for the manufacture of

graham flour. These, however, are in operation only occasionally. The old power plant having about outlived its usefulness, the author was asked in January, 1905, to look into the condition of that plant, the work it was doing, its efficiency, etc.

Former Power Plant.

The old plant was installed in 1881, and was, therefore, nearly 24 years old. It consisted of two horizontal return flue boilers, of the " compromise " pattern, so popular at that time. The boilers were each 48 in. diameter, 20 ft. long, and had 12 6-in. flues. They were set in a single furnace, with common grates, 4 ft. long, 9 ft. wide; iron chimney 36 in. diameter, 73 ft. high. These boilers were rated at 50 h.p. each. This type of boiler, as is well known, can readily be crowded to twice its rated capacity, and even more, which conditions of operation are not at all uncommon. The boilers were fed by a " doctor " — a vertical fly-wheel feed pump — having two single-acting plungers, $2\frac{13}{16}$ in. diameter by $4\frac{1}{2}$ in. stroke, discharging through an iron pipe coil heater. The water supply came from a driven well 7 in. diameter, 235 ft. deep, the water in which stood at a depth of about 60 ft. below the surface with active pumping, and was of the uniform temperature of 58 to 60 degrees fahr. the year round. Water from this well was delivered into an overhead tank by means of a deep well pump, with 6 in. by 24 in. steam end and $3\frac{3}{4}$ in. by 24 in. single-acting water end, its speed being from 25 to 50 rev. per min. The mill was driven by a simple non-condensing Corliss engine 16 in. by 42 in., speed 70 rev. per min., built by the Smith, Beggs & Ranken Machine Company.

Test of Old Plant.

In order to get an approximate idea of the efficiency of the old plant an informal test of 4 hr. duration was run on the afternoon of January 3, 1905. The coal burned was weighed, the engine indicated and the output of flour noted. An attempt was also made to estimate the water consumption by counting the speed of the " doctor," but the results were only approximate, and are of doubtful value. The results were as follows:

Average gage pressure	98.2 lb.
Flour made, bbl., total	68.25
Flour made, bbl. per hr.	17.06
Average speed of engine	70 rev. per min.
I.h.p.	171.2
I.h.p. per bbl. per hr	10

I.h.p. per bbl. per day of 24 hr.	0.42
Rating of engine	135 h.p.
Proportion capacity developed was of rating	125 per cent.
Coal burned, total	3 325 lb.
Coal burned per hr.	831 lb.
Coal burned per hr. per sq. ft. grate	23.1 lb.
Coal burned per hr. per i.h.p.	4.85
Coal burned per bbl. flour	48.7

The coal consumed was screened lump from the Jupiter mines near the DuQuoin, Ill., costing $2.73 per ton delivered. This coal is above the average quality which comes to the St. Louis market, but is, of course, not quite equal to the highest grades from southern Illinois, such as the Big Muddy.

The grain elevator, requiring about 20 h.p. additional, was on during this run, but not the corn or graham mills. The horse-power developed was a little large, owing to the heavy feed customary in cold weather. It is possible also that the mill had not gotten down to smooth, well lubricated running conditions after the holiday shut down.

Conclusions and Recommendations.

The result of this informal test, and the conclusions and recommendations based thereon, were handed the company in a formal report on January 18, 1905. Special emphasis was laid on the fact that the modern flour mill offered exceptional opportunities for high fuel economy on account of its large and uniform load and the long hours of service, always at least 12 hr. per day, and often 24. It is a matter of some surprise that this field has been given so little attention heretofore among mills of average size. Among the plans analyzed in the Wolff report were the following:

A. The continued operation of the plant as it stood, adding only a new boiler. Estimated fuel saving over old plant, 20 per cent.

B. The adding of condensing apparatus to the existing engine. Total estimated saving, 40 per cent.

C. Substitution of two new cylinders for the old single cylinder, making the engine a compound, and running it non-condensing. Total estimated saving, 40 per cent.

D. Adding two cylinders, and also condensing apparatus. Total estimated saving, 55 per cent.

E. Installing an entirely new engine, to be compound non-condensing. Total estimated saving, 40 per cent.

F. Installing a new engine, to be compound condensing. Total estimated saving, 55 per cent.

Each scheme was fully discussed, its probable cost estimated and the probable resulting economy computed. Each plan contemplated the substitution of a new boiler of such capacity as was necessary, as follows:

Plan A, a 150 h.p. boiler, 72 in. by 20 in. with 74 4-in. tubes.

Plans B, C and E, a 115 h.p. boiler, 66 by 20, with 56 4-in. tubes.

Plans D and F, a 100 h.p. boiler, 60 in. by 20, with 46 4-in. tubes.

Further investigation indicated that the addition of a superheater to the boiler would bring about an economy fully justifying its cost, and this course was decided upon. No information was available as to the exact economies which would result, but a study of other installations indicated that an economy of at least 10 per cent might reasonably be expected.

An investigation was also made into the desirability and cost of economizers; also of tile and concrete chimneys, but the resulting advantages in this particular installation did not seem to warrant the additional investment.

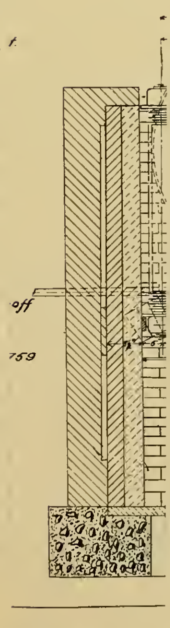
Due consideration was given these data, with the result that the undersigned was directed to prepare detailed plans, and secure proposals on the basis of Plan F, involving an entirely new plant, especially designed for the work.

The New Plant.

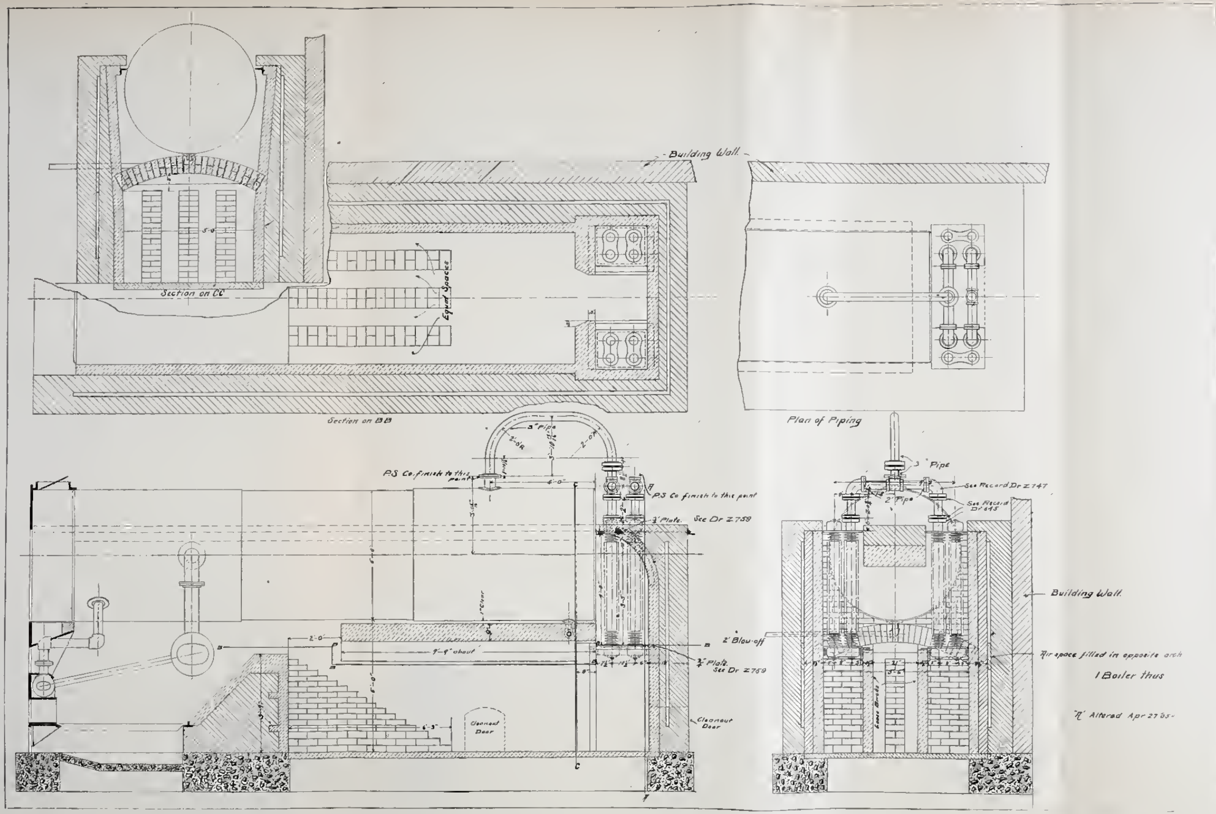
In due time proposals were received and contracts awarded for the new equipment. This was duly delivered and erected, consisting in detail of the following:

Boiler. — The admitted advantages of the water tube type for many kinds of service not being important in this installation, the ordinary horizontal return tube boiler was selected. Its dimensions were 60 in. diameter, 20 ft. long, with 46 4-in. tubes. Repeated evaporative trials have shown this to be a very economical type of boiler. The detailed design involved some special features, such as adjustable overhead supports, absence of steam dome, none being required for steady load, overlapping strips for brick work, etc. Deflecting dampers were placed over the four upper rows of tubes to divert a larger percentage of the gases into the lower flues. A sheet iron chimney 30 in. diameter, 100 ft. high, was placed immediately over the smoke box extension. The heating surface of this boiler was 1 173 sq. ft. in the


Plan of P



NG COMPANY,



Foster Superheater and Kent Wing-wall Furnace for the Wolff Milling Company, New Haven, Mo.

shell proper, and 58 in the down draft furnace, total 1 231, which at 12 sq. ft. per h.p. gives the boiler a rating of 102.6 h.p. The grate surface being 22.5 sq. ft., the ratio of heating to grate was 54.71 to 1.

Boiler Setting. — The excellent performances in St. Louis of the down draft form of furnace led to its adoption, not on account of its smokelessness, but for its economy in fuel. A 10-in. drum with hand hole was used for the front header, and a 20-in. drum with man-head for the rear. The grates were made of 2½ in. extra heavy pipe, 2⅞ in. outside diameter, 5¼ in. centers, there being 12 in the furnace. The lower grates were of the ordinary type, 5 ft. in length. In addition the Kent wing-walls and arches were placed in the rear of bridge wall, primarily to insure a more uniform heat for the superheater, but they have no doubt added to the efficiency of the plant. The upper fire door of the down draft furnace extended the entire width of furnace, without columns, permitting access to and inspection of every portion of the fire bed.

Superheater. — This was of the Foster make, and was guaranteed to heat 3 000 lb. of steam per hr., at 150 lb. pressure, to 500 degrees fahr. The steam on leaving the boiler shell turns to the rear, and enters the superheater, dividing into two paths, each consisting of four elements. The steam descends through the furnace into a return header, then ascends, and then repeats the path, discharging finally into main steam line overhead. The other branch takes a similar course. The units consist of a length of 4-in. pipe about 4 ft. 4 in. long, surrounded by cast-iron washers, closely fitted to pipe, and of about 10 in. outside diameter. These receive the direct impact of the heat and bear the brunt of the wear and tear, protecting the pipes themselves, which are under pressure, and they serve furthermore as storage reservoirs of heat. Inside the pipes are placed pipes 3 in. diameter, which force the steam in its passage through the superheater to traverse the annular channels close to the walls of the pipe, in thin cylindrical streams, thus greatly facilitating its heating. The superheater is located in the area way between rear head of boiler and rear furnace wall. The gases pass first through the down draft furnace, and the Kent wing-walls and arch, and are discharged through a throat immediately below rear head of boiler. The two divisions of the superheater are located on each side, and are surrounded by fire brickwork, being thus protected from direct contact with the flame.

Engine. — This contract was awarded to the St. Louis Iron & Machine Works of St. Louis, and covered one of their standard tandem Corliss engines, high-pressure cylinder 12 in. diameter, low-pressure 24 in. diameter, stroke 36 in., speed 80 rev. per min. This engine, with an initial pressure of 150 lb., cutting off at ¼ in the high-pressure cylinder, and with 26 in. vacuum, is rated at 175 h.p. It was provided with a fly wheel 15 ft. in diameter, 30 in. face, built crowning for a 28-in. belt. Both cylinders were controlled by a single governor and eccentric, there being no necessity for severe overloads. A receiver between high- and low-pressure cylinders was provided and furnished with reheating coils to be supplied with superheated steam. The packing of pistons, stuffing boxes and all joints was metallic, and of a type specially adapted to superheated steam.

Condenser. — This was of the Wainwright horizontal type, having a cast-iron shell 18 in. diameter, containing 96 1-in. corrugated copper tubes, 96 in. long, with 256 sq. ft. of tube surface. The tubes were arranged in four groups with horizontal partitions, the water — which is inside the tubes — having to traverse the entire length of the condenser four times. This condenser is rated at 200 h.p. and was guaranteed to condense 3 000 lb. of steam per hr. to a 26-in. vacuum with not exceeding 6 500 gal. of water at 60 degrees fahr. Immediately under the condenser was located the wet vacuum pump, 5½ in. by 8 in. by 7 in. The surface type of condenser was selected at a slightly greater cost than the jet type, on account of its increased simplicity and reliability and its giving a supply of purified water for the boiler, thus doing away with the necessity for frequent cleaning and the risk of burning.

Deep Wells and Pumps. — In addition to the original deep well referred to above, the Wolff Company sunk another well of the same dimensions and depth, installing in same the old deep well pump. For the old well an order was placed for a new deep well pump, 6 in. by 36 in. steam end, and 5¾ in. by 36 in. single-acting water end. The new well was located at a point some 30 ft. distant from the original well, and probably tapped the same vein of water. It was found that the two pumps working together gave a somewhat greater capacity of water than either of them singly, but both cannot be operated to their full capacity at the same time. They furnish, however, a sufficient supply of water for circulation through the condenser, and discharge directly through same, provision being made to take some of the

warm discharge water for "make-up" water through the hot well to boiler, and also for filling overhead tank for use when the plant may be shut down.

Pipe Work. — This was made simple and direct, bends being used wherever possible. The main line carrying superheated steam was made 3 in. diameter, and provided with extra heavy valves and fittings. This size was much smaller than ordinary practice, and as its total length — including travel through superheater — was nearly 100 ft., its use was attended with some misgivings. The best practice of the present day is to reduce these sizes, particularly with superheated steam. A receiver 18 in. diameter, 36 in. long, was, however, placed at the engine immediately above 4-in. throttle valve, with a view of equalizing the pressure at the engine. No separator or drain was provided for same. All joints in high-pressure line were of two thicknesses of sheet copper. Traps were provided on exhaust from high-pressure cylinder and on reheating coil in intermediate receiver, the former discharging to waste on account of the oil, and the latter discharging into hot well. The exhaust leaving low-pressure cylinder crosses engine room under ground, then rises to a T, above which is the 8-in. free outlet to atmosphere, in which was located a Blake relief valve. From side of T the exhaust continues to the Wainwright condenser through a Bundy grease extractor. The latter drains into a 12 in. by 40 in. receiver with water column, which receiver is provided with a high-pressure connection from boiler and a drain to sewer. It has been found necessary to blow this receiver out about once every 3 hr. This is done by closing the valve from separator, opening steam valve slightly and then opening drain. The air pump discharges into the hot well, which consists of an old boiler shell 40 in. diameter, 8 ft. long, set up vertically. It has a perforated false bottom, above which there is placed some 3 or 4 ft. of hay, which is frequently renewed. There is a surface overflow or blow-off, and the water filters down through the hay into a lower compartment, from which it passes to the "doctor." The original extraction of grease before entering condenser, and the further filtering through hay, with an occasional blowing off of the surface of hot well, have been found entirely satisfactory thus far in keeping oil out of the boiler. In the hot well there is an automatic float controlling a valve in a branch pipe from the circulation discharge, which admits such make-up water as may be required. The feed water passes from the hot well to the "doctor," thence through coil in heater to boiler. It was found

impractical to use an open heater, and a Hoppes shell 34 in. diameter by 8 ft. long from the old plant was retained and filled with 1.5 in. pipe and return bends. Into this heater the exhaust from the two well pumps, the "doctor," and the air pump are discharged, with very efficient results in heating the feed water, as is shown by the test. In order to insure a thorough distribution of the steam in the heater, the atmospheric discharge was reduced to 1 in., which has been found ample. The condensation in heater passes to hot well and forms no inconsiderable portion of the make-up water necessary. The main steam line carrying the superheated steam is covered with magnesia covering of double thickness. The top of boiler, and other steam lines carrying saturated steam, were given a single thickness of the same covering. This included intermediate receiver, the high-pressure receiver having double thickness. An independent steam line from the boiler supplies saturated steam to the four pumps.

Before the formal efficiency test was conducted, an investigation into the drop in pressure between the boiler and engine was made with a test gage. It was found that when the engine was running at about 150 h.p., with 155 lb. gage pressure, there was a drop of but 4 lb. between the boiler and the receiver at engine throttle. This included the entire 3-in. steam line and the superheater, and was found to be about equally divided between the superheater and the pipe line.

Power Transmission. — In the old plant the Corliss engine shaft extended through mill wall, where the mill was driven by a complicated system of spurs and gearing, the overhead transmission being by means of a vertical shaft. This was changed, doing away with a considerable portion of the gears. Provision was made for extending the main mill shaft into old engine room and locating on same an 80-in. pulley, which was driven by a belt direct from engine fly wheel, the new engine and boiler rooms being located in a new building directly west of the old one. The distance between wheel centers was 28 ft. 9 in. The transmission was by means of a 28-in. Shultz 3-ply "Sable" leather belt, rated at 300 h.p.

In arranging the plant, particular attention was given to compactness and easy access to all parts, the intention being that a single man should do the firing and look after the power plant. As less than 400 lb. of coal were to be fired per hr., and as the load was practically constant, this requirement was not deemed unreasonable. The boiler and engine were so located

that the attendant might pass quickly from the fire room to the engine, all starting and controlling mechanism being near at hand. The three main pumps were also located near by. The engineer, standing in the door between boiler and engine room, has his eye upon practically the entire power plant, and is within a half dozen steps of all features requiring frequent attention. The only parts at any distance are the main engine bearing and crank pin, which require only occasional inspection.

Preparations for the Test.

The gages around the plant had already been compared with a standard test gage, and their corrections noted. Three calibrated water measuring tanks were shipped to New Haven, and erected in such position as to take either the water discharged into hot well from condenser, or the make-up water. The discharge from these tanks went direct to the "doctor." The drain from heater was disconnected from hot well and allowed to go to waste, as it was of no particular importance in the test. The discharge from engine receiver trap was also disconnected from hot well, and carried to a barrel for periodical weighing. Tested scales were provided for the coal and ashes. The steam being superheated, no calorific determinations for dryness were necessary. The blow-off pipes from boiler were plugged. An indicator was provided for the high-pressure cylinder, and another for the low-pressure, so that cards could be taken from both simultaneously. A revolution counter was attached to the valve motion of the engine, so that its exact number of revolutions for any given interval could be ascertained. An ample supply of thermometers was provided for measuring temperatures of steam at outlet of superheater and at engine receiver; also where steam entered and left reheating receiver. Thermometers were inserted in chimney, feed line near boiler, hot well, measuring tanks, circulating water inlet and outlet, and for external and internal air. Draft gages were provided for measuring the chimney draft, both at base of chimney and in fire box between grates. The feed water supply was from air pump discharge as far as it would go, the remainder or make-up water being from circulating discharge. It will be noticed that this make-up was necessarily greater, and that the temperature of feed water through "doctor" was lower, than it would have been had the drains from heater and engine trap gone to hot well as in ordinary running. A previous test showed the water

from condenser to be 120 degrees fahr., and in hot well, 142, a gain of 22 degrees.

A preliminary run was made on the afternoon of August 14, to see that all instruments and apparatus were in working order, and to drill the assistants in their special duties.

The Test.

This was begun at 8 A.M., August 15, 1905, and continued uninterruptedly until 6 P.M. Indicator cards and observations of all general readings, such as pressures and temperatures, were taken every 20 min. The moment of observation, however, was at the middle and not at the beginning of each 20 min. interval. Independent logs were kept by each observer, or assistant, and these were double checked wherever possible. No attempt was made to reach all the refinements possible in modern engine testing, where exact heat balances are desired, or where important questions hinge on the result. It was desired simply to ascertain with accuracy the essential facts of mill output, horse-power temperatures, and water and coal consumption.

The Fuel. — This was large nut, or No. 1, washed, from the Carterville district in Williamson County, southern Illinois. It was quite uniform in size, clean and of excellent quality. A small shovelful was thrown into a sample barrel from every barrow load throughout the run. At the close, this was quartered down into a small sample and preserved in a Mason jar for later calorific determination and proximate analysis, if desired. Previous investigations of this coal indicate that it has a probable calorific value of about 12 000 B.t.u. per lb., which figure has been used in the present computations. The coal was delivered to the fireman in 500-lb. lots, the time of the first fire from each new lot being noted on the log. No special instructions were given the fireman, other than to carry uniform boiler pressure, uniform thickness of fire, and to avoid air holes. The fires were thoroughly cleaned just before beginning the test, and filled with fresh coal, and when this had burned down to the point of requiring replenishing, the time was noted and the test begun. A similar cleaning of the fire was made just before the close of the run, after which the fire was charged with weighed coal, which was again allowed to burn down at the close. The fireman was a new man, who had never fired a boiler before the starting up of the new plant, but, having no preconceived ideas, had nothing to unlearn, and proved very faithful

and efficient in doing what was expected of him, a characteristic not always found in more experienced stokers.

Water. — This was put through calibrated measuring tanks, Nos. 1 and 2, with knife-edge overflows, these being filled and emptied alternately into No. 3. Previous to starting the test, tank No. 3, which serves as a reservoir for the boiler feed pump to draw from, was filled to overflowing. Tank No. 1 was also filled, ready for use, and No. 2 was empty. At the moment of starting the test the height of water in the boiler and hot well were noted, and the feed pump began to draw from No. 3. At the same instant the discharge water from air pump and condenser was turned into No. 2. Tanks 1 and 2 were then filled and emptied alternately, except when the supply from condenser ran short of the boiler's demand, when an extra and intermediate tank was filled from the circulating water from condenser. The height of water in boiler was kept close to the starting point all day, and was brought to exact level at the close. Temperature readings were taken at the time of overflow in each measuring tank, so as to get its exact volume and weight from charts representing previous calibrations.

Miscellaneous Data and Records. — Indicator cards were taken from both ends of both cylinders simultaneously every 20 min., and all gages and thermometers were read, and the pressures and temperatures noted on logs.

Results of the Test.

Boiler and Superheater (see Exhibit B). — The boiler pressure was maintained fairly uniform, averaging 150.7. The draft at base of stack ranged between 0.3 in. and 0.5 in., and in fire box between grates 0.1 in. and 0.3 in. These readings were rather lower than anticipated, and are due, no doubt, to the high external and low stack temperatures. The latter ranged between 362 and 460, a very low figure, due in part to the presence of superheater, and in part to the fact that the boiler was not being crowded. The temperature of steam leaving superheater ranged between 512 and 535 degrees fahr., a remarkably steady figure, being an average superheat of 158.0 degrees. At the engine receiver the range of temperature was from 475 to 505, an average superheat of 125.7, showing a loss of superheating in transmission of 32.2 degrees fahr. The ashes and unconsumed coal weighed back were 11.26 per cent. of the coal burned, a rather higher figure than anticipated. The coal burned per sq. ft. grate hr., 16.27 lb., was considerably lower

than is considered best for high efficiency. The low draft in this case does not warrant high rates of combustion, but 20 to 25 lb. would have given better results. Some shortening of grate surface would be economical if the present load and fuel were continued, but as greater loads and possibly inferior coals may sometimes be encountered, it is probably unwise to make any change. The evaporation in lb. of water per lb. coal, 7.45 actual and 8.93 equivalent, is very good. This was due not only to the excellent grade of coal used, but also to the design of the boiler and furnace, the superheater, the deflecting dampers and other essential details. As the superheater was treated as a part of the boiler, it became necessary in computing the factor of evaporation to take into consideration the total heat of superheated steam, which involves, of course, the much disputed question of its specific heat. The most complete and accessible data on this point were found in a paper by Mr. Geo. A. Orrok, member American Society Mechanical Engineers, published in *Power* for August, 1904. The efficiency of 71.9 per cent. secured on the combined boiler and superheater (based on an assumed calorific value of the fuel) is excellent, although slightly higher results have been secured under particularly favorable conditions. Had the boiler been running at 25 per cent. higher rating, and fired by a stoker of experience in making tests, and in getting the greatest possible work out of the fuel, a still better figure would undoubtedly have been reached.

It will be noticed that the work being done called for a boiler h. p. of only 94.4, which was but 93 per cent. of the boiler's rating.

Steam Engine (see Exhibit A). — It will be noticed that the vacuum was low, the range being from 21 to 23½ in., averaging 22.8. This is due, no doubt, in part to the high external air temperature, and also to some small leaks still existing in exhaust and condenser pipes, although these had been very carefully gone over. The reheating coil in intermediate receiver is supplied with superheated steam, and raises the temperature of the steam between high and low pressure cylinders 35 degrees. The speed of the engine averaged a little lower than that intended, 80 rev. per. min. The load was fairly well divided between high- and low-pressure cylinders, which balance will be brought still closer with increase of vacuum. The engine itself was slightly underloaded, and will give better results with 20 per cent. more work.

It is interesting to note the exact quantities of water con-

sumed and their disposition. The amount chargeable against the engine was,

From condenser	lb.	18 212.14
Drain from high-pressure exhaust to waste	lb.	34.00
Drain from grease extractor to waste	lb.	468.29
Total steam passing through engine	lb.	18 714.43
Add condensation in reheating coil	lb.	652.00
Total chargeable to engine	lb.	19 366.43

The total water chargeable to boiler was,

From condenser, as above		lb. 18 212.14
From reheater	652.00 lb.	
From condensation in feed water heater (computed)	273.18 lb.	
Balance made up from circulating system,	8 321.20 lb.	9 246.38
Total		lb. 27 458.52

Eight thousand three hundred and twenty-one and two tenths lb. is the amount of water which would have to be purchased if the owners did not have a private supply, as would be the case in any large city taking its water from a city system of distribution.

Of the total make-up water, 9 246.38 lb., the following amounts are chargeable to the engine:

Drain from high-pressure exhaust	lb.	34.00
Drain from grease extractor	lb.	468.29
Drain from reheater	lb.	652.00
Total	lb.	1 154.29

The remainder, 8 092.09 lb., is the amount properly chargeable to the expense of operating the auxiliaries, and to other miscellaneous leakages and losses.

The coal per i.h.p. hr. (2.43 lb.), which includes auxiliaries, is good. For the engine alone the coal per i.h.p. hr. is 1.71 lb. The water consumption per i.h.p. hr. of engine alone, 12.75 lb., is exceptionally gratifying, considering the low vacuum and the underloaded engine. This figure establishes a new record in this field, and is very creditable to the builders of the engine. The percentage of water used in the auxiliaries, 29.5, is high, although the figure includes, of course, all other incidental losses and leakages. These auxiliaries consist of the four pumps already referred to, which are of the single cylinder, throttling, non-condensing pattern, having water rates of undoubtedly

100 to 125 lb. per i.h.p. hr. It was thought that there woul be no material loss from this source as their exhausts were to be used for heating the feed water from the hot well temperature to the boiling point, 212. The desired temperature of feed seems to have been reached, and it is possible that some economy might be effected by turning one or more of the auxiliaries into the condenser.

Still further economy in fuel could, of course, be secured by driving these auxiliaries from the main engine, but as this would involve complicated and expensive construction in the way of pulleys, tighteners and variable speed devices, it was not thought desirable for a plant of this size and character.

Circulating Water. — An attempt was made to measure this water during the test, but this was found impracticable. After the close of the day's run, the discharge from the well pumps was turned into measuring tanks. The average speed of the small pump during the day had been 31 single-acting strokes per min., but on account of increased pressure through the hose, we were unable to run it above 25, at which speed its actual rate of discharge was 1 477 gal. per hr. Its displacement at this speed, allowing 5 per cent. for slip, was 1 623 gal. Had we been able to speed it to 31, it would have discharged at the rate of 1 831 gal.

The large pump was run and also tested at 17 strokes, at which speed it discharged at the rate of 3 241 gal. per hr., its displacement as above being 3 921. These figures show that either the pumps were not filling, or that they had excessive slips. When the two pumps were tested together they threw water at the rate of 4 800 gal. per hr. With higher steam pressures and lower discharge head, as in regular service, they would undoubtedly deliver the 5 200 gal. per hr. called for by the condensing of the amount of steam delivered by the engine. No accurate test of the capacity of these wells could be made, but it is believed that they will deliver as a maximum from 6 000 to 6 500 gal. per hr. The low temperature of this water, 58 to 60 the year round, makes it exceedingly valuable for condensing.

Mill Output. — As 17.77 bbl. of flour were made per hr. with the consumption of 368.5 lb. of coal, the amount per bbl. was 20.73. This also is an excellent figure and one which establishes a new record in plants of this kind in this part of the country, with ordinary Illinois coals. It should be remembered that this result was secured with an inexperienced fireman, a

low vacuum on engine, an underloaded boiler and engine, with some feed water heat being wasted, and with a plant not thoroughly warmed. The plant is shut down every night for 12 hr., and requires some time during the forenoon to get everything thoroughly warmed. The loss in efficiency due to shutting down is shown by the fact that the coal consumed per bbl. during the afternoon was 20.2 lb., although this included the cleaning of fires. The h.p. per bbl. of flour made per hr., 8.6, represents good practice.

EXHIBIT A — RESULTS OF ENGINE TRIAL.

Date		August 15, 1905
Duration		10 hr.
Dimensions of Cylinders:		
High-pressure cylinder, diameter		12 in.
Low-pressure cylinder, diameter		24 in.
Length of stroke		36 in.
Rated h.p.		175
Pressures (Gage):		
Steam at boiler		150.7 lb.
Steam at main receiver		148.5 lb.
Steam at intermediate receiver		18.7 lb.
Vacuum		22.8 in.
Temperatures:		
External air		92.0 degrees fahr.
Indoor air		92.0 degrees fahr.
Steam in boiler		365.9 degrees fahr.
Steam leaving superheater		524.8 degrees fahr.
Steam at main receiver		490.6 degrees fahr.
Steam entering intermediate receiver		254.9 degrees fahr.
Steam leaving intermediate receiver		289.9 degrees fahr.
Water in hot well		117.2 degrees fahr.
Water in feed pipe		208.4 degrees fahr.
Circulating water entering condenser		60.0 degrees fahr.
Circulating water leaving condenser		102.6 degrees fahr.
Superheat:		
Leaving superheater	524.8—365.9	158.9 degrees fahr.
In main receiver	490.6—364.9	125.7 degrees fahr.
Leaving intermediate receiver	289.9—254.9	35.0 degrees fahr.
Speed:		
Rev. per min., average		77.1
Piston speed, ft. per min.		462.6
Horse-Power (Indicated):		
High-pressure cylinder	85.74	56.4 per cent.
Low-pressure cylinder	66.19	43.6 per cent.
Total	151.93	100.0 per cent.
Proportion i.h.p. is of rated capacity		86.8 per cent.

Coal:		
Rind		Carterville washed
Size		No. 1 (large nut)
Total consumption		3 685 lb.
Per i.h.p. per hr.		2.43 lb.
Water:		
From condenser	18 212.14 lb.	
From grease extractor	468.29 lb.	
From h.p. exhaust	34.00 lb.	
	18 714.43 lb.	
From reheater coils	652,00 lb.	
		19 366.43 lb.
Balance (to auxiliaries, leaks, etc.)		8 092.09 lb.
Total		27 458.52 lb.
Per i.h.p. hr. engine, alone		12.75
Per i.h.p. hr., including auxiliaries		18.07
Percentage of total water used in auxiliaries		29.5
Approximate quantities of circulating water passing through condenser per hr. (computed)		5 180 gals.
Flour Output:		
Bbl. of 196 lb. each, made during trial		177.72
Bbl. of 196 lb. each, made per hr.		17.77
Bbl. of 196 lb. each, made per 24 hr.		426.48
Horse-Power:		
Per bbl. made, per hr.		8.606
Per bbl., made per 24 hr.		0.3585
Coal Consumed:		
Per bbl. flour made		20.73 lb.

EXHIBIT B — RESULTS OF BOILER TRIAL.

Date	August 15, 1905
Duration	10 hr.
Number of Boilers in Operation	1
State of Weather	Clear
Dimensions and Proportions:	
Kind of boiler	Hor. return tubular
Dimensions of shell, diameter and length	60 in. by 20 ft.
Number and diameter of tubes	46-4 in.
Grate surface, upper, 5 ft. wide, 4½ ft. long. Area	28.5 sq. ft.
Water heating surface	1 231 sq. ft.
Superheating surface. Foster	
Percentage of air space in grate (upper)	42.5 per cent.
Ratio of grate surface to water heating surface	1 to 54.7
Chimney dimensions, height and diameter	30 in. by 100 ft.
Average Pressures:	
Steam in boiler, by gage	150.7 lb.
Steam in boiler, absolute	165.4 lb.
Draft suction. Inches of water:	Uptake, 0.432; fire box, 0.211

Average Temperatures:

Of external air ....92 degrees fahr.
Of boiler room ....92 degrees fahr.
Of escaping gases entering chimney ....409.4 degrees fahr.
Of feed water entering boiler.....................208.4 degrees fahr.
Of steam in boiler...................................365.9 degrees fahr.
Of steam leaving superheater.....................524.8 degrees fahr.

Fuel:

Kind of coal .... Hurricane washed
Size of coal ....No. 1 (large nut)
Cost per ton of 2 000 lb., delivered................................$2.90
Calorific power by calorimeter. B.t.u. per lb., assumed....12 000
Theoretical evaporative power, from and at 212 degrees fahr. in lb. water, per lb. coal..........12.42 (assumed)
Total quantity consumed ....3 685 lb.
Total ash, clinkers, and unburned coal.....................415 lb.
Proportion of ash, etc., to coal....... ....11.26 per cent.
Total combustible burned ....3 270 lb.

Combustion per Hour:

Coal actually consumed ....368.5 lb.
Combustible actually consumed ....327.0 lb.
Per sq. ft. grate surface, coal..............................16.37 lb.
Per sq. ft. grate surface, combustible......................14.53 lb.
Per sq. ft heating surface, coal.............................0.300 lb.
Per sq. ft. heating surface, combustible....................0.266 lb.

Calorimetric Tests:

Quality of the steam (dry steam = 1)...............................100
Amount of water entrained in the steam...................0 per cent.
Amount of superheating, 524.8—365.9...........158.9 degrees fahr.

Water:

Amount apparently evaporated...........................27 458 lb.
Amount actually evaporated ....27 458 lb.
Factor of evaporation (allowing for superheat)..............1.1986
Equivalent evaporation into dry steam from and at 212 degrees fahr. ....32 911 lb.

Economic Evaporation. Per lb. of coal:

Water actually evaporated....................................7.45 lb.
Equivalent from and at 212 degrees fahr.....................8.93 lb.
Per lb. of combustible. Water actually evaporated ....8.39 lb.
Equivalent from and at 212 degrees fahr....................10.07 lb.

Evaporation per Hr.:

Water actually evaporated ....2 745.8 lb.
Equivalent from and at 212 degrees fahr..................3 291.1 lb.
Per sq. ft. heating surface. Water actually evaporated .. 2.23 lb.
Equivalent from and at 212 degrees fahr......................2.67 lb.
Per sq. ft. grate surface. Water actually evaporated....122.03 lb.
Equivalent from and at 212 degrees fahr....................146.3 lb.

Efficiency:

Percentage of total calorific power utilized, or efficiency (on assumed B.t.u.) ....71.9 per cent.

Water evaporated for $1.00 worth of fuel, actual.........5 140 lb.
Cost of evaporating 1 000 lb. of water (actual).........19.45 cents
Coal consumed per boiler h.p. per hr....................3.86 lb.
Cost of same.................................... 0.559 cents

HORSE-POWER:
Actually developed on basis of 34½ lb. water evaporated
per hr. from and at 212 degrees fahr.................95.4 h.p.
Commercial rating, at 12 sq. ft. heating surface........102.6 h.p.
Proportion capacity developed is of commercial rating..93.0 per cent.
Heating surface required to develop 1 h.p...............12.9 sq. ft.

SOME NOTES ON FUEL BRIQUETTING IN AMERICA.

By Clarence M. Barber, Member of the Civil Engineers' Club of Cleveland.

[Read before the Detroit Engineering Society, December 29, 1905.]

America has always been, and is now, favored above almost every country on the globe in the supply of fuel. In no other land is it so abundant, of so good a quality or so varied in kind.

Our extensive fields of bituminous and anthracite coal have been developed beyond those of any other country, and we have yet untouched great fields of baser fuel in the shape of lignite and peat, some of which are quite important on account of geographical location. The forests, once of first importance, are no longer a factor to be used in estimating the fuel resources of our country.

The annual supply of coal in this country has been increased enormously within the past decade. In 1895, it was 193 000 000 tons. Our production in 1904 was 352 000 000 tons and estimates indicate that 1905 statistics will show that we have mined over 1 000 000 tons per day. But the consumption has also increased beyond what any one could have reasonably anticipated.

That this wonderful production only just meets the constantly increasing demand is shown by the fact that the price to the consumer does not diminish, but rather tends to increase each year.

Of this great quantity, only about 21 per cent. is anthracite. To the remaining 79 per cent. is chargeable the dark gloom that hangs over so many of our homes and factories.

Briquetted Fuel in Europe.

The American traveler in Europe notes with interest the use there of briquetted fuels. Coal briquettes are in large piles at the railroad coaling stations and are seen in use, more or less, everywhere, but especially in Germany, Austria-Hungary, Belgium, France and England.

Our United States consul-general, Frank Mason, in his reports states "that briquettes form the principal domestic

fuel of Berlin and of the cities and districts in Germany. They are used for locomotive and other steam firing and are employed for heating in various processes of manufacture. For all these uses they have three tangible advantages. They are clean, convenient to handle, light easily and quickly, and burn with a clear, intense flame. They make practically no smoke and are, with all, the cheapest form of fuel for most purposes."

At another point in his report Mr. Mason says: "Berlin, although a busy manufacturing city, ranks as one of the cleanest and best cities in Europe. One of the first things usually noticed by American and English travelers visiting the German capital for the first time, is the absence of that cloud of dusty smoke that overhangs so many towns and cities in our country."

Again Mr. Mason says: "If American municipalities, beyond the economic range of anthracite, are ever emancipated from their present vassalage to the smoke incubus, it will be through the enforced use of one or more of three forms of prepared fuel, viz.: coke and fuel gas made in closed ovens from bituminous coal, and briquettes made from lignite, peat and other inferior materials by processes which have been invented, tested and proven to be efficient by the older and more economical countries of Europe."

Recently, and especially within the last ten years, considerable advancement has been made in this country in the way of introducing coke and gas as domestic fuel in cities. Coke from by-product coke ovens has been so favorably received that the prospect for the more extended use of this cleaner fuel is very encouraging.

Fuel briquettes are not made, or in use, in this country, except to a very limited extent and only very recently. Mr. Robert Schorr, at San Francisco, has recently installed a successful plant. Some peat briquettes are successfully made in Canada. There are some other briquetting plants, but those that have come to our notice are yet in the experimental stage.

In Germany alone the annual production is 13 000 000 tons. France produces over 3 000 000 tons and other countries bring the world's production up to over 25 000 000 tons.

Materials for Briquettes.

Briquetted coke breeze makes a very superior and clean fuel, and almost smokeless briquettes can also be made from anthracite culm and bituminous slack, as well as also from lignite and peat.

Fuel briquettes may be made from almost any combustible substance. Some materials, such as lignite and peat, can be formed into briquettes by pressure alone in a suitable press, but most materials require the addition of some adhesive substance as a binder. There is hardly a vegetable, animal or mineral carbonaceous material that can be thought of, that some one has not attempted to raise to a marketable value by briquetting, and, as usually the substance is a refuse, the financial gain, if it can be briquetted successfully, suggests at once an attractive investment for capital.

Methods of Manufacture.

In general, it may be said that the materials that have been most successfully briquetted for fuel are bituminous slack, anthracite culm, coke breeze, lignite and peat. Each of these substances requires different treatment on account of its different properties. They cannot be worked in precisely the same manner.

Some materials require more or a different binder than others, or none. Generally the moisture must be reduced by drying, but lignite works well with 17 per cent. of moisture. Again, great or little pressure may be required, etc.

If we take as an example anthracite culm, the process of briquetting, without going sharply into detail, may be as follows: In the first place, to prepare for briquetting, part or all of the following operations may be necessary: Washing, drying, crushing or screening. The first is necessary if the ash is too high and the last is almost always necessary to prevent foreign substances from injuring the machinery.

The prepared culm is ready to be combined with the pitch, which has been previously cracked or crushed to 0.5 in. and under. It is also not unusual to add a third element, such as a small percentage of bituminous coking coal. The ingredients are proportioned by some form of a measuring device such as three screw conveyors, or better, a Trump measuring machine. The carefully predetermined proportions are accurately measured dry, and the mixture is now spouted to a disintegrator or mill, where it is reduced to the proper fineness and thoroughly blended. The pulverized material is now passed to what is called the kneader, where superheated steam melts the pitch and revolving blades stir the mixture which has now become a hot paste. It is next forced into molds, pressed and ejected therefrom, usually upon some form of a conveyor.

The hot briquettes become hard as the pitch cools and after a few minutes on the slowly moving conveyor they may be loaded into cars for shipment. There is a so-called wet process, which differs from the above only in the manner of introducing the pitch. The pulverized coal having been thoroughly dried, is heated and stirred by moving blades, while the melted pitch is mixed with it. The resulting paste is then molded as above.

There are many other processes, but those used for bituminous and anthracite coals or coke breeze differ from the above chiefly in the kind of binder or the type of press used.

Binders.

Coal-tar pitch is used more extensively than any other binder; in fact, we understand that in Europe the market for coal-tar pitch is supported by the demand for that product in the manufacture of fuel briquettes.

Within the last few years the supply of pitch has been greatly augmented by that obtained from by-product coke ovens. This fact alone has given the briquetting industry in Europe great assistance, and the lower price of pitch from the same cause in this country is a new inducement for the development of the enterprise here.

Owing to the fact that the cost of pitch has been an important factor in the expense of producing briquettes, many other materials have been tested with varying results. Asphalt pitch is quite successfully used. Sago flour is used with a very small quantity of pitch by an English firm, with, it is claimed, a satisfactory result. A low grade of molasses obtained from sugar factories, and a mucilaginous liquor obtained from paper mills, have also been used. Rosin is used to some extent. Quite a number of inorganic substances are also on the list of binders. These contain more or less ash, and are, therefore, undesirable.

Practically all other binders have lost in importance in proportion as good coal-tar pitch has been reduced in price. It is acknowledged to be the best binder. Its points of advantage are chiefly: that it is a strong adhesive which sets quickly on cooling; that it contains practically no ash, so that the briquettes show rather less ash than the materials which it binds together; that it protects the briquettes against hygrometric changes, so that they will not suffer when exposed in wet or freezing weather; and further, that on account of its high calorific value, it increases the thermal units in the briquettes above that of the other ingredients.

Its points of disadvantages are its cost and the fact that when used in considerable quantity it causes a slight smoke when the fire is being started or when a fresh charge is added. The smoke is very thin and light and lasts but a few moments. It is reduced to a minimum when the quantity of pitch is small, and if the furnace has a suitable draft it may not be observable at all.

Pitch.

Coal-tar pitch, as all doubtless know, is obtained from coal tar by distilling off part of the volatile oils. The pitch may be soft or hard according to the amount of the volatile oils remaining when the distillation is stopped. If continued until all the volatile oil is removed, then there will remain simply a dry fixed carbon or coke. The value of pitch as a binder for the manufacture of the briquettes depends chiefly upon the proportions of oil and fixed carbon the specimen contains. This point was established by a careful series of tests made at the Coal Testing Plant of the United States Geological Survey at the Louisiana Purchase Exposition.

The softer specimens of pitch, such as those used for pavements, melting at about 25 degrees cent. and the roofing pitch melting at 38 degrees cent., must be shipped in barrels, as they often flow like wax at summer heat or from the heat absorbed from direct sunlight even in cool weather. The harder specimens, or those which melt above about 55 degrees cent., can be handled in bulk or in sacks, and do not require barrels if kept shaded from the sun. This matter is quite important as an element of the cost of pitch. A saving of between $2.00 and $3.00 per ton is effected if the pitch does not require to be shipped in barrels.

Both soft and hard pitch are used for the manufacture of briquettes, but we note that most European manufacturers are using rather hard pitch.

Briquetting Presses.

That part of the machinery of a briquetting plant which is used for handling the material, crushing, screening, elevating into bins, measuring and mixing the ingredients, etc., is all such as may be seen at work elsewhere in this country. The press used for briquetting, while it is often very similar to our brick-making machines, is really the only special machine required. It is also the most expensive and important. The

press must be adapted to the kind of material to be worked, to the size and shape of the briquettes desired, as well as to the quantity to be produced in a unit of time.

In Europe, where the industry has been developing for the last forty years and more, the press question has been pretty well exploited, if we may judge from the number of different kinds of presses that are in use and offered for sale by manufacturers.

In general, the presses are divided into classes according to their mechanical design. I will note a few of the more important classes.

Open-Mold Presses.

Open-mold presses are those in which the material is forced through a tube-shaped mold by a reciprocating plunger or a screw. The continuous column delivered from the tubular mold is usually cut by wires to the desired length of the briquettes. Sometimes the reciprocating plunger produces a briquette at every stroke, each being formed against the preceding one, the tube being long enough to contain several briquettes. In this case the column issuing from the mold being composed of separate briquettes does not require to be wire cut, as the briquettes fall apart as they issue from the mold. The resistance against which the plunger or screw acts in this case is the friction of the material against the sides of the mold. Open-mold presses are used in this country for wire-cut brick, and those of the reciprocating plunger kind are worked not far from Detroit on peat, for which they are well adapted. It is evident that the consistency of the material used in these presses must be carefully gaged, as the density of the briquettes and the pressure will depend on the viscosity of the material fed to the press.

Closed-Mold Presses.

Of these there are a large number. There are single-plunger presses, in which the material is filled into a mold and pressed by a single plunger against a solid resistance, which may be a plate covering the opposite end of the mold. This press is successfully worked on lignite, but it is not generally adopted for other coal.

The double-plunger press is simply a mold with a pair of opposing plungers. In this press the material receives pressure on both ends at once. Where heavy pressures are required, and especially on large briquettes, foreign engineers recommend this press.

Most of the larger briquette factories of Europe use some form of the double-plunger press. In the Couffinhal type, which is one of the most successful in use, there is a large disk, usually about 54 in. in diameter and about 5 in. thick. This disk revolves in a horizontal plane. The molds, usually 8 in number, are simply holes cut through the disk. The material is filled into the molds and receives pressure from below and above at the same time by a pair of vertical plungers which usually give a pressure of about 2 000 lb. per sq. in. After each stroke and when the plungers are withdrawn, the disk revolves far enough to bring another mold under the plungers, and the already pressed briquette is moved under an ejecting plunger and forced out upon a conveyor. Presses of this type, working on large briquettes, produce as high as 15 tons or over per hr. When working on small briquettes the production falls as low as 2 tons per hr. and under.

Another type of the closed-mold press is that which has been known as the eggette press of Belgium. This machine has two tangent cylinders whose axes are parallel. The cylinders roll together and the eggettes are formed in the semi-egg-shaped depressions which cover the surfaces of the cylinders.

This eggette machine is quite largely used. It has the advantage of yielding a rather large production, usually about 5 tons per hr. Its disadvantages are, that it requires more power than almost any other machine; it is difficult to keep in good running order and it is necessary to adjust the mixture of material to suit the machine rather than for any other conditions. Furthermore, there is more or less material wasted.

Size of Briquettes.

It may be noted that the machines producing the larger briquettes usually yield them at a somewhat lower cost than those producing the smaller sizes. This accounts for the fact that some consumers break up the larger briquettes for domestic use. In America, however, the domestic trade demands small briquettes. There seems to be a tendency also in Europe at present toward the smaller sizes.

For shipment and use in steamboats, where economy of space is of the first consideration, large rectangular briquettes are used because of the quantity that can be piled in a given space. A common briquette in France for this purpose is one weighing 10 kg. or 22 lb. Briquettes measuring 7 in. by 4 in. by 4.75 in., and weighing 2 kg., 500 g. or 5.5 lb. are now used for

ocean shipment and also for locomotive use. Rectangular briquettes from these sizes down to less than 1 lb. each, and eggettes weighing a few ounces, are common for domestic use.

Briquettes of every conceivable solid figure have been made.

It is important to note that good briquettes may be stored out of doors for years without suffering any deterioration. Spontaneous combustion in large piles is said to be impossible.

So important are the considerations of economy of space and safety of storage, together with some other advantages, that we are told the very best coal is sometimes ground up and briquetted for the bunkers of steamships.

Conclusion.

In the matter of introducing the briquetting of fuel into this country, it is but natural to regard it as simply a transplanting of a foreign industry from European into American soil, but it seems to be much more than this. Quite a number of attempts at starting the industry here have failed. The writer examined, quite carefully, into the causes of some of these failures and obtained some valuable information.

In regard to cost of manufacture we note that Mr. Robert Schorr, of San Francisco, in his valuable paper in the *Transactions of the American Institute of Mining Engineers*, February, 1904, gives the cost per ton of briquettes in western America, as follows:

Labor, exclusive of stacking	$0.16
Oil and grease	.006
Sundry stores	.01
Steam fuel	.04
Interest and depreciation	.05
Total	$0.266

The total of these figures coincides so closely with the writer's own estimates that we believe them to be sufficiently correct for approximate estimates near any large city.

In regard to the cost of pitch we have not been able to obtain close figures, but we believe this item may be estimated for the eastern or middle states at about $7.50 per ton, or an 8 per cent. mixture would give for the briquettes per ton $0.60. This gives a total, exclusive of the cost of anthracite culm, slack coal or coke breeze, of $0.87 per ton of briquettes.

If the cost of anthracite culm, for example, is taken at $0.50 per ton, and 67 per cent. is used, this item would give $0.33 per ton of briquettes. If also we add to this 25 per cent of slack coal

at $1.60 per ton, we should have for this item $0.40. This would give a grand total for the cost of anthracite briquettes $1.60 per ton.

In regard to the selling price of briquettes there are no figures at hand for this country. It is estimated, however, that they will command a price between the best bituminous and anthracite coals.

In regard to the proper location for a briquette plant, of course, this depends on the location of a supply of the material to be used and of the market. At the anthracite mines there is sufficient culm to last several briquetting factories many years and the market of the large eastern cities is near.

Many other places there are where, on account of coke plants and large coal distributing points, coke breeze and slack coal are to be had. Some of these places are at long distances from the mines and have an advantage on freight for a higher selling price. Lignite and peat are important sources for the future briquetting industry in America.

Editors reprinting articles from this JOURNAL are requested to credit the author, the JOURNAL OF THE ASSOCIATION, and the Society before which such articles were read.

ASSOCIATION OF ENGINEERING SOCIETIES.

Organized 1881.

VOL. XXXVI. FEBRUARY, 1906. No. 2

SUBTERRANEAN WATER SUPPLY.

BY JOHN RICHARDS, MEMBER OF THE TECHNICAL SOCIETY OF THE PACIFIC COAST.

[Read before the Engineering Congress (Lewis and Clark Exposition), at Portland, Ore., June 29, 1905.]

THE brief monograph to be read, if it be long enough to require explanation, will differ from papers such as are usually presented on occasions of this kind, in that the author is almost wholly unacquainted with the subject treated. This should have notice at the beginning.

There is scarce a subject connected with engineering science or the arts that has escaped modern investigation, especially in those branches that affect the social and economical conditions of population, but in some recent experience I have encountered problems that indicate an omission that very nearly affects a large part of the population on this coast, especially in California, — the subject of subterranean water supply.

Of course we must recognize the subject, as one surrounded by peculiar and obscure circumstances, completely removed from observation, and resting, as it always must, largely on conjecture and the limits of exploration by boring. Still, there is a good deal that can be deduced from geological and other premises, experience and observation that would be of value if systematized, arranged and made available to those who desire to discover and procure water in this manner.

The erosion of the steep volcanic hills and mountains in California has carried down into the valleys extended beds of

gravel, some of it worn and mixed with sand, some of it in the form of crushed or disintegrated stone that contains 40 per cent. or more of pure water and is disposed at various depths from 20 to 200 ft. below the surface. Ten ft. is named as a minimum for pure water, because close or compact strata of that depth will insure sufficient filtration to remove deleterious matter.

The water is in some cases flowing at a rate dependent upon the coarseness and compactness of the gravel, 3 to 10 ft. an hour; in other cases is impounded and static, like lakes on the surface. The latter is by all means the most desirable source for water, because the area of infiltration into wells or pits is as their whole exposed perimeter, while in the case of intercepted or flowing water, the area of infiltration from one direction, and after saturation is exhausted, is not more than one third as much, however great the general supply may be.

These gravel strata are disposed with but little respect to present surface indications, in their immediate vicinity at least, and deviate in an extraordinary manner as to thickness, the number of strata and their depth, so that no area of any extent can be predicated on wells, except by boring them near together.

In some cases the water level rises and falls 20 ft. or more with the seasons; in other cases from a like depth rises above the surface, forming what are called artesian districts of considerable area. As before remarked, the extent of these water-bearing gravel deposits does not seem to bear any particular relation to the present physical conditions of surface, except that they are fluvial and in the bottoms of valleys; not always, perhaps, because one of the most copious supplies I have met with, near San Jose, is at a depth of only 40 ft. from the surface, but at an elevation of 90 ft. above the general level of the pumping districts around that city.

Twenty years ago I had my attention drawn to the copious supply of water contained in the gravel strata around the south end of San Francisco Bay, and constructed, as I believe, the first successful centrifugal stage-pumping machinery to raise this water for irrigating purposes. From 100 to 300 gal. per min. could be drawn from a single tube well, or 500 gal. from two or three adjacent wells, and the supply seemed inexhaustible, even when the pumping stations were situated near together.

To afford a sufficient supply, the well tubes had to traverse an aggregate of 8 to 10 ft. of gravel strata, found usually 100 ft.

or more below the surface, the machinery being set 40 to 80 ft. from the top, or within suction distance of the water level. The data acquired, except as to adaptation of the pumping machinery, were meager. There were no circumstances to determine the rate of horizontal flow or the amount of percolation for a given area, no indication of the source of water, which might have been from precipitation on the hills or higher lands, by infiltration from the bay or general percolation over the surface of the valley.

I will digress to say that water from gravel strata should be raised by centrifugal pumps whenever the quantity is sufficient to permit a constant pumping volume. These pumps made for the required pressure are economical and not injured by sand, which is always present in such water when raised rapidly.

Centrifugal pumps that have their impellers inherently balanced and no running joints to maintain against water pressure have no metallic contacts, no valves and are very durable. When the thrust on the impellers is compensated by disks or other contrivances, such pumps are perishable and soon circulate instead of discharging water.

One point in respect to subterranean water deserves especial remark — the character of the water procured from underground sources. Respecting this, there is a widespread or even general belief that such water is impure, and, if we accept common facts, this may be conceded, but I will venture the statement that not one well in fifty is protected from surface infiltration, not even tube wells, and under these circumstances the water must be contaminated.

On the contrary, wells sealed against surface infiltration supply pure water, and when it is drawn from gravel, it is in every way, except aëration, preferable to impounded surface water. It is, in fact, filtered water held in a state of purity, preserved by natural means far more complete than any that can be artificially devised.

Having recently become a member of a water purveying company that proposes to procure a subterranean supply in a valley near San Francisco, I naturally cast about for information respecting gravel deposits, wells, surface infiltration, the permanence of general infiltration or supply, the relation of such water supply to overlying lands; also the extent to which such gravel deposits are indicated by the geographical environment and the trend of rock ledges that determines underground flow.

The paucity of the information obtainable led me to believe

that a short paper read here would direct attention to this subject and cause observance and collation of data by engineers interested in procuring and purveying water.

My own professional experience, outside of the few facts mentioned, has been confined to raising and impelling water, an art that, while it is far from perfected, is falling more and more within the field of computed results and standard machinery, especially on the Pacific coast, where I am proud to claim our engineers have a foremost place, taught them by various peculiar circumstances, including extreme heads and pressures that have no precedent in any other parts of the world.

I have mentioned my connection with stage centrifugal pumping on this coast, and as a matter of interest to the congress, and with permission of the Chair, I will supplement the foregoing remarks with a statement made and attested in 1902, respecting what I believe to be the first application of this stage method to actual commercial use, in this or other country.

This statement, prepared for use in interference proceedings in the United States Patent Office, is as follows:

The Development of High-Pressure Centrifugal Pumps on the Pacific Coast.

It is common opinion throughout the Eastern states that centrifugal pumping has reached a more advanced stage on this coast than in other parts of this country, and this is certainly true in respect to many, if not most, of the varied uses to which these machines are applied, especially as to an early use of the high-pressure type that is now engaging especial attention in all countries.

The writer has been several times requested to explain this matter and give some of the facts relating to this "evolution," especially in respect to what are called high-pressure centrifugal pumps. This I cheerfully do, because the principal facts and data are at this time ascertainable, and in a few years will be lost, as is common in such cases; also for the reason that some legal proceedings now being conducted in the East involve the origin and progress of these pumps in this country.

Down to 1880 there had not been any regular manufacture of centrifugal pumping apparatus on this coast. A great many of a cheap kind were imported here to replace reciprocating pumps for irrigating purposes, because the water, when drawn from the gravel strata, was filled with sand and fine

gravel that soon cut away packing and destroyed sliding joints of any kind exposed to the water.

It was soon discovered that centrifugal pumps had no sliding contacts, no valves and were not affected by the sand and gravel, and besides, could be employed for large quantities of water. This and other reasons led to a manufacture of such machines here, the circumstances being as follows:

In 1880, the writer, then a director and manager of the San Francisco Tool Company of this city, was called upon to examine a pumping plant employed to drain one of the San Joaquin Islands, near Stockton, that belonged to some of the shareholders of the San Francisco Tool Company.

The machines in use were found to be very imperfect, and the writer recommended that a new and better pump be procured from one of the Gwynne firms, at London, with whose work he was familiar. There was no time for this, however, and he undertook the construction of a cheap centrifugal pump, which, with a new steam engine, removed the water and at the same time reduced the coal consumption from 4 500 lb. to 1 800 lb. per day.

This circumstance led to a contract with the city of Sacramento for a vertical draining pump to clear the surface water at the southeast end of the city; and this again to other pumps, especially for irrigating purposes, until a regular business was established, the San Francisco Tool Company being then sole makers on this coast.

Up to 1883 it was a common belief, even yet entertained by many people, that centrifugal pumps cannot be operated against a head exceeding 40 ft.; but in October of that year Dr. Chapin, who held the position of state entomologist in California, called at the works to ascertain whether he could not procure a series of such pumps to raise water 83 ft. on his ranch near Santa Clara, Cal.

I had little faith then, and now, in series pumps operating at different levels, and proceeded to design a pump, as shown in Fig. 1, in which the water passed consecutively through two impellers without being diverted from its plane of revolution normal to the axis.

Working drawings and a pump were made from this sketch, and the pump was started at the Tool Company's works in Stevenson Street, by Mr. A. F. L. Bell, now of this city, first as a single pump, with one impeller left out.

The pressure attained at the speed arranged was 30 lb.

per in. The second impeller was then put in and the pressure rose to double, or 60 lb. per in., and a telegram was sent to Dr. Chapin saying the company would contract for a pump to operate at a head of 85 ft.

This pump was made and erected in February or March of 1884 by Mr. C. H. Gorr of San José, and was perhaps the first stage-centrifugal pump set in practical operation in this country, having the distinct features of present practice, including the division plate and return passages between the impellers.

This pump attracted the attention of Mr. Henry Booksin of San José, a prominent fruit grower there, and a mechanic, with whom a contract was made to construct a two-stage pump

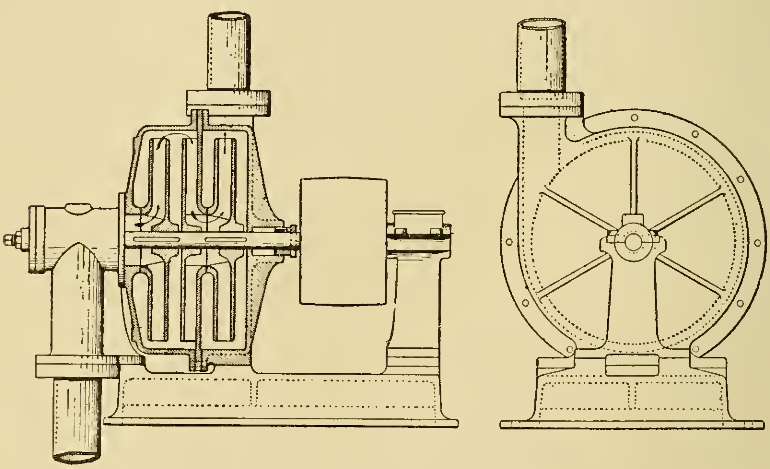


Fig. 1.

to operate against 90 ft. of head and raise 750 gal. per min. This pump is shown in Fig. 2, and it is to be questioned if there has ever been another made with more precision or more care in workmanship.

The work done by the San Francisco Tool Company was at that time of a very high grade, mostly on machine tools, and the pump was as well made as an iron lathe or planing machine. It was erected in a narrow pit, 80 ft. below the surface, in a fixed position, and the season being a very dry one, the water rose over the pump and there remained for *ten years or more*, the pump running each year from two to three months, night and day, raising sometimes at the rate of 1 000 gal. per min., and

received during this time no repairs whatever, not even examinations, being submerged and inaccessible.

This is an example of endurance that proves the advantage of good work and strong proportions, but is by any standard a strange result. In 1898, after fourteen years of service, this pump was dismantled and raised to the light again. All the bolts and attachments had to be cut away because of corrosion, but the main parts were preserved by Mr. Louis Booksin until the present month, and have been purchased by the Turbine

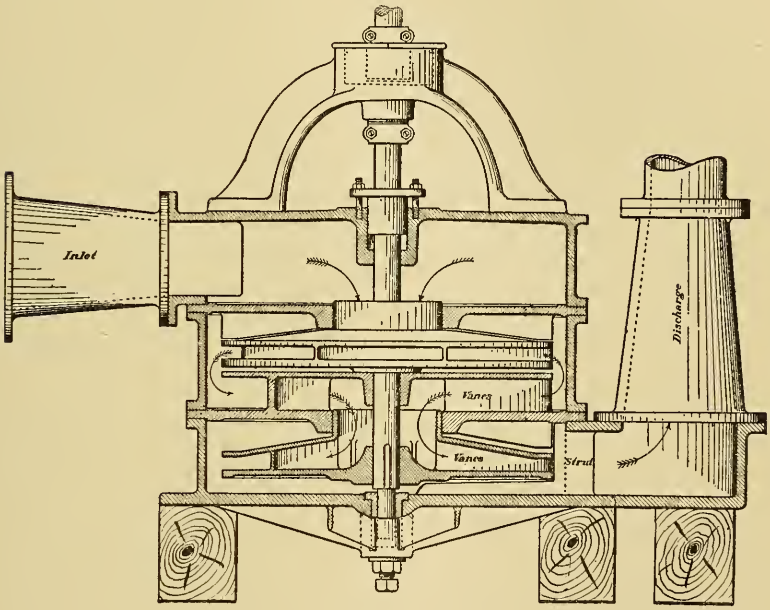


FIG. 2.

Pump Company, of New York, as a memento of early practice in stage pumping. The drawing, Fig. 2, was made from these parts.

In 1885 I went to Europe and made there some investigation and inquiry respecting centrifugal pumping, but found no stage pumps were in use at that time, and it is a fair inference that the pumps above referred to were the first to be practically and continuously operated.

With the exception of some special pumps designed between 1885 and 1900, I gave no special attention to centrifugal pumps until the advent of the stage pumps of Messrs. Sulzer

Brothers, of Switzerland, who produced a refinement in such machines by a purely scientific treatment or, as we may say, of "kinetic" construction that differed in respect to water ducts of careful proportions, a great increase in the rate of rotation and in the diffusion of water from the impellers that converted the energy of rotation into pressure.

This was an important advance; one that called for accurate and intricate workmanship, that, however easy it might be in this famous works, was not attainable in common shops. In that year I set about an attempt to balance the impellers of stage pumps, to simplify and cheapen their construction; also to attain an equal pressure on the sides of the impellers to prevent circulating leakage.

After several years of experiment, these things have been accomplished in such degree that a new type of high-pressure pumps will soon be so far perfected that their construction can be submitted to the world through the usual channels.

Engineering effort in this direction on the Pacific Coast is to a great extent a sequence of the extended use of water-raising and impelling machinery demanded by the physical circumstances of the country and its industries.

THE PRINCIPLES GOVERNING THE VALUATION FOR RATE-FIXING PURPOSES OF WATER WORKS UNDER PRIVATE OWNERSHIP.

By Arthur L. Adams, Member of the Technical Society of the Pacific Coast.

[Read before the Pacific Coast Engineering Congress (Lewis and Clark Exposition), at Portland, Ore., June 29, 1905.]

Purpose and Scope of Paper.

The constantly increasing interest among the thinking people of this country in the evolution of some process by which so-called "public service corporations" may be brought under such government control as will secure protection to the public against unfair discrimination, insure the making of no greater average charges for the service rendered than such service is reasonably worth, and at the same time afford such properties immunity from spoliation under the guise of lawful regulation, is justification for the careful consideration of any important aspect of this very difficult problem.

That many of the questions involved are of a character calling for solution by those familiar with works construction and management, and that the aid of such men is frequently sought to assist the courts in reaching right conclusions in cases arising under existing laws, fully warrants, in the opinion of the writer, this presentation.

Legislation on the subject may as yet be regarded as in an experimental stage, and the resulting accumulation of experience has demonstrated the unwisdom of many of the methods employed in attempts to establish such control.

The whole subject needs most careful consideration by those whose training best fits them to devise methods with a clear vision as to their practical consequences.

The regulation of rates by governmental agency, whether such regulation takes the form of the fixing of rates outright or the revision of rates made by the corporation, presupposes the right of the corporation to receive a fair and just return upon the value of its property.

The ascertainment of what constitutes the fair and equitable value of such properties is always the important initial

step. It gives rise to most interesting and complex questions involving the consideration of ways, means and cost of construction; of the subsequent practical conduct of such works as to their operation, maintenance, growth and financial management, and the value to the public of the service rendered. It also calls for the exercise of the judicial temper, a keen sense of justice and fair dealing, and often no small measure of imperviousness to public criticism.

The first before-mentioned requirements are certainly such as must be possessed by any successful engineer of high professional standing; and impartiality, discriminating judgment and equanimity under trying conditions should certainly characterize the members of a profession so often called upon to decide between contending interests.

It is, therefore, the writer's belief that our profession will fail of its privileges and its duty if it does not influence in a very large degree the final formulation of wise legislation on this subject, and sound court interpretations.

The principles governing the determination of value of all such properties are quite similar; and though this paper deals with but one class, as its title indicates, the writer hopes it may prove of interest to specialists in other lines.

No effort will be made to treat the subject of appraisement even of water works in all its aspects, but rather to assume conditions likely to prevail in bringing most public service corporations under governmental control or supervision as to rates.

By the adoption of certain premises it is intended that all exceptional cases arising from special contracts, special legislation, or otherwise, shall be turned aside and the question become a general one as to what, under the more ordinary circumstances, constitutes the just and reasonable value of water-works properties of private corporations devoted to and being used for the public convenience. And even when thus restricted, the limitations of space will confine the writer to the discussion of the leading principles and factors only.

It is therefore presupposed:

First, that works have been built under legal authority imposing no restraints affecting their value.

Second, that the value of the property is sought as the basis for the fixing of such rates by governmental authority as shall return to the owners a fair and just compensation for the service which is rendered.

Fundamental Factors Influencing Value.

The question of what constitutes reasonable and just value under the above conditions ordinarily necessitates the consideration of the following questions:

(1) Is the plant of such character as to enable it to properly fulfill the obligations assumed of supplying the public with a suitable water service, both present and future?

(2) What has been the cost of the works?

(3) Has its acquisition been characterized by the exercise of a reasonable degree of prudence and engineering skill?

(4) Has the policy of the rate-fixing or other legislative authorities been such as to make necessary any special financial policy in the conduct or acquisition of the water-works properties, with special reference, —

First, to the refunding of capital invested in structures of perishable character, or having a usefulness limited as to time.

Second, to the allowing of interest returns upon the properties acquired for the future use of an increasing population.

(5) Would a reduplication of the existing structural works cost less or more than the present structural works have cost?

(6) Would the construction of substitutional works cost less or more than the present works have cost?

(7) Have the real estate and water-producing properties of the company increased in value?

(8) Has the franchise any value?

(9) Does any special value attach to the fact that the company has an established business capable of producing an adequate revenue?

(10) Does the value of the service rendered to the consumers limit the value of the property?

No single formula can be made sufficient for the determination of value in all cases. Each of the above enumerated factors and possibly others may, under certain circumstances, properly exercise an influence in determining the final result. The degree of weight which attaches to each may vary greatly with circumstances. No final conclusion can be intelligently reached until all have been considered and their relative importance weighed, often one against the other.

Value is, therefore, not a quantity which can be determined with any mathematical accuracy. Its limitations as to maximum and minimum can usually be fairly well defined.

When circumstances require the naming of a specific figure, it can only be reached by the final, possibly arbitrary, exercise of personal discretion after reasoning processes have so far as possible narrowed the field of its final employment.

The application of the result, however, in determining rates is of itself subject to no absolutely defined rule and admits of a considerable range of use without doing violence to natural standards of fairness and equity.

That value, therefore, cannot be determined with mathematical nicety does not detract from the usefulness of an appraisal, though it be in a sense approximate only.

The before enumerated fundamental queries will now be taken up in their order for the purpose of showing their relation to reasonable value and to some extent the manner of their application. These factors are so closely interrelated that it requires careful analysis to make clear their bearings, the one toward the other, and the limitations which each imposes upon the result sought.

The Fitness of the Plant to Fulfill the Obligation which the Company has Assumed of Supplying the Public with a Suitable Water Service, both Present and Future.

The relations between the public and the water company are of a mutual character. If the public owes the company a sufficient revenue to operate and maintain its plant and pay to its owners a reasonable return upon its value, no less does the company owe to the public an abundant and uninterrupted supply of good potable water. It owes the exercise of such energy, prudence, skill, economy and capital as will successfully anticipate contingencies of accident or increased demand, and such as will at all times enable it to supply water at the least cost to the consumer consistent with justice to its stockholders.

Fair treatment and a fair valuation on one side presupposes the maintenance of an efficient and economical service on the other, and the *vice versa* is equally true. It is, therefore, proper that inquiry be made into the character of the plant used and intended for supplying water. Such an inquiry, particularly in regions of lesser rainfall, naturally falls into the following order:

(1) The water supply as already developed, as to quantity and quality.

(2) The adequacy and suitability of the provision for future increase.

(3) The present consumption and possible future demand.

(4) The suitability of the works for conveyance and distribution.

The scope and character of the investigations necessary to develop the desired information embraced under these various heads will, of course, differ greatly in different cases. With but one exception they call for no comment here. The appropriateness of each subject in determining value would seem to be beyond question. The second has, however, been called in question and claims attention. It has been contended often, and even so held by certain courts, that in determining value, only properties actually employed for the delivery of water or maintenance of the service at the time in question should be included. In view of this sentiment, it is well, therefore, to remember that the duty of a water company to maintain an efficient service implies and imposes the responsibility for anticipating the future increase of consumption, that the available supply may never for one moment fall below the proper and legitimate demand.

This responsibility in the supplying of a city means the forecasting, often for many years, of the probable population and per capita consumption.

It often means the necessity for the acquisition of necessary lands, water rights and storage reservoirs years in advance of their actual use for the delivery of water, lest when imperatively needed they be impossible of acquirement or are purchasable only at a prohibitive price.

The building of structures of the magnitude often required is in itself not infrequently a work of several years.

It therefore follows that at all times the water company must know in advance just where and in what quantities its future water supplies are to be secured.

The relation of such acquisition to present value will more appropriately be taken up under a later head.

The Cost of the Works and Its Relation to Value.

Cost alone is seldom determinative of the value of any enterprise. Such value may be very materially influenced by the worth of business, that is, the amount of its earning capacity, present and prospective; or by the probable cost of building

a new plant of equal or better efficiency, or by other considerations.

But in the case of a system of water works devoted to public use at a rate of compensation fixed, not by its owners, but by governmental agency, and so fixed as to yield as a net return a moderate rate of interest only on the value of the property employed, the reasonable actual cost of such properties to their owners would seem to represent in almost all cases the lowest value upon which a rate schedule can with any claim to equity be based; and though said cost may be by no means determinative of full value, it may be regarded as the most important factor involved and the one usually determinative of the minimum of value.

Reasons for this view are simple, direct and conclusive because founded on the practical necessities of water-works construction, operation and financial management. They may be enumerated as follows:

First.— The purveying of water in a modern city is a necessity, upon which the welfare and very existence of the community depend. This service must, therefore, for the public good be performed by either private or public initiative, regardless of how great may be the necessary cost.

Second.— When rates are so fixed as to cover only the expense of maintaining the plant in a serviceable condition and pay a current rate of interest on the value of the property, such a policy precludes the company's making any financial provision for safeguarding its investments against depreciation by subsequent reductions in the market price of materials and labor, or otherwise.

Third.— Water-works properties of magnitude are never created at one time. They are the product of years of growth, being increased and extended a little at a time from year to year in compliance with the demands of the community growth. In many western states water service must largely precede instead of follow population, while the supply must always be maintained in quantity well in advance of present demand.

Fourth.— The imagining of a system created as of one time at current prices of lands, materials and labor, is wholly fanciful and has never supplied a large city with water, though such an assumption, as we shall see, at times has its use.

Fifth.—The final test of accuracy in every estimate is the actual cost of the completed work, built as such works are of necessity actually built. Actual cost of the completed work

must, therefore, be entitled to far greater weight in determining their value than any mere estimate resulting from the unavoidable assumption of impossible or unnatural conditions, and the use of assumptions in lieu of the results of accomplished fact.

Sixth.— Materials and labor once purchased and used as a part of a system of water works are no longer commodities in the market with value fixed by the rise and fall in prices of new materials and labor. At a certain cost these things have already entered into the creation of a system and are devoted to a fixed and permanent use; and why should one adopt as a starting point in the determination of structural values a standard subject to daily and almost unaccountable market variations in preference to a standard that actual accomplishment has unalterably fixed? There appears no good reason for so doing so long as the statements of actual cost are worthy of credence and their reasonableness unimpeached.

If, on the other hand, the rate-fixing powers have made such liberal provision in the revenue as to permit in addition to adequate returns upon the property value the making of ample provision for safeguarding the property against loss through falling prices of materials and labor, or the deterioration of perishable materials, or the abandonments incident to changing conditions, as well as other possible causes of loss, then cost becomes of lesser importance in determining a just value of all structural works, and corresponding greater weight may attach to estimated cost of works of duplication or substitutional equivalent without working injustice.

In determining the actual cost to a company of its plant, recourse can usually be had to its book record. The reliability of such record can by a competent engineer generally be determined by a study of the property. Not with exactness, of course, but within such reasonable limits as is worth while attempting in arriving at a final determination of present value, involving, as it does, so many broad considerations.

An important question, however, relates to the disposition of losses early in the history of the plant, arising from a lack of revenue, and their relation to cost and value.

The correctness of the policy of adding annual deficiencies in the operating of a plant to investment in determining the cost of a property to its stockholders as contrasted with other forms of investment paying current rates of interest is, of course, admissible. That such a course throws any light upon the

question of value of the property is not so clear and needs amplification.

In ordinary competitive enterprises such a computation would indicate nothing more than the loss which had been sustained in comparison with more remunerative forms of investment. If, however, as in the case of almost all water works, the enterprise be of a character which does not usually and therefore is not expected to yield adequate returns for some years after its inception, making the anticipation of this condition necessary to the successful financing of the enterprise and its establishment on a firm basis, such early losses may be charged to investment and become a measure of the money value of that intangible though none the less real asset known as "established business," or quality of being a "going concern," or possessing the ability to earn an adequate revenue, which the courts have recognized in certain important cases.

With a meritorious enterprise there should, of course, come a time in a reasonable period when the earnings become sufficient to pay a proper return upon the investment inclusive of such early losses, otherwise it must be classed as unprofitable, and its value be less than its cost.

In the case of a public utility limited as to its possible earnings by an extraneous rate-fixing body unnecessarily to a sum less than sufficient to constitute a proper return upon the investment, it would appear that redress from this condition should be sought in the courts rather than by charging such losses to investment for a long period of years.

Save in so far, therefore, as these losses may be said to be a measure of the cost of establishing the business, they do not of themselves, unsupported by other considerations, constitute a basis of value, and the most that can be claimed for them on their own account is that such losses from lack of revenue during the early history constitute the cost of and are therefore a measure of the value of that asset known as "established business."

Losses of capital in abandoned structures because of lack of sufficient revenue for refunding the money thus invested must be regarded as in much the same position as losses from inadequate interest returns from the same cause.

Such losses will, however, seldom accrue to the cost of establishing the business, for this should ordinarily be accomplished within the life of all structures of importance.

It is true that failure on the part of rate-fixing powers to

afford this revenue when it could reasonably be allowed without imposing excessive rates does a gross injustice to a water company, which should not be tolerated, but if such structures are permitted to long pass out of use without enforcing compensation for them, they cannot be said to still have value save possibly as a moral claim.

The Degree of Prudence and Engineering Skill Exercised in the Acquisition of the Water-Works Property and Their Relation to Value.

In considering this subject it is necessary to ascertain:

First, whether no greater price has been paid for land and water rights than was reasonably necessary.

Second, whether the structural works have been designed and built on sound engineering lines and with a proper regard for a wise economy.

The first calls for no special comment.

In passing on the second it must be remembered that no small part of engineering is the adapting of means to ends, that there are almost no established standards of design, that no two men will ever plan works along identical lines, and that a wide range of liberty of choice must be accorded the engineer.

The appraiser has a right to expect and demand that the works shall have proven reasonably successful, considering all the conditions which have influenced or controlled their design and construction, with average practice as his standard rather than his own personal preference. Beyond this he should be sparing of criticism. Unqualified failures due to inexcusable ignorance or bad judgment must lead to rejection in determining value, but the appraiser will often find difficulty in determining in his own mind where to draw the line between what is excusable and what inexcusable. If he is a man of wide experience he is least likely to indulge in hasty or harsh condemnations, realizing that engineering is very far from being an exact science; that to some extent it will always be the unexpected that happens; that defects are more easily discoverable under the test of actual trial, and that criticism is far easier than creation.

The Past Policy of the Rate-Fixing Authorities in Making Provision for the Refunding of Capital Invested in Structures of Perishable Character or Having a Usefulness Limited as to Time, and in the Allowing of Interest Returns on Property Acquired for the Future Use of an Increasing Population, and the Relation of such Policies to Equitable Value.

Depreciation as ordinarily applied to water works results either from the wear and tear incident to use and exposure to the elements, or from enforced abandonment on the score of economy or of changed conditions.

For example of the first, iron pipes are gradually rendered useless by corrosion until renewal becomes necessary; for example of the second, pumping stations may have to be abandoned because the water supply has become of uncertain purity, or because increased consumption or later and better designed machinery renders the old unsatisfactory on the score of economy, even though such machinery may still be in as good condition as it ever was.

In any event, depreciation represents a shrinkage or diminution of tangible property value which must be written off to expense as a part of the cost of maintaining the service, and which must be paid for out of the revenues if the capital so invested is to be preserved unimpaired.

There are two ways by which this may be done:

First, by the establishment of a fund out of which all renewals and losses from abandonments are made good, the said fund being maintained by uniform periodical contributions from the revenues; or

Second, by meeting the actual expense of renewals and abandonments each year out of the revenues of the same or succeeding year.

Either policy preserves intact the invested capital and charges depreciation where it belongs as an item of expense.

The former method is for some reason to be preferred, chiefly because it equalizes this item one year with another, thus permitting a more uniform water rate, and because it is the practice almost always followed, though in an indirect way. For most water works, unless prevented by restrictive legislation, make provision in their revenues each year for the redemption of a portion of their bonded indebtedness, and under all ordinary conditions such provision exceeds in amount and ren-

ders unnecessary the making of any other provision for depreciation.

It scarcely need be pointed out that a policy of making no allowance at all or of making insufficient allowance for depreciation, and then discarding the structures after abandonment in the determination of value for rate-fixing purposes, is nothing else than confiscation, which by a process of gradual absorption tends to ultimately consume all the capital invested in such structures, with the result of having afforded water service to the consumers at just that much less than cost to the company.

The power that fixes the revenue determines the method by which depreciation shall be cared for, if cared for at all. If that power has made possible the provision of no fund for this purpose, but has, on the other hand, established the policy of allowing depreciation only as the renewals are actually made, the policy should be pursued to its logical and right conclusion and no structures when abandoned be disallowed in whole or in part in determining value until its cost shall have been in the same proportion refunded from the revenue.

Structures which have passed out of existence or which no longer serve a useful purpose may not be included, whether the matter of their depreciation has in the past been rightly or wrongly dealt with.

Structures which are still useful should not be depreciated in determining value without provision being made in the revenues for refunding their cost.

When a charge is properly made against the otherwise value of a property because of structural depreciation, the amount of that charge should not be greater than the estimated present value of an interest-bearing sinking fund which, contributed to annually during the average useful existence of the plant, will equal in amount the investment in the various parts at the end of their usefulness.

If it is the duty of a water company to use reasonable diligence to secure for the future as well as for the present an abundant water supply, a proposition seemingly beyond question, and if this can be accomplished most prudently by the acquisition of properties in advance of their actual requirements for the supplying of water, it certainly seems that such property before its development is in the true sense in use, since it has been purchased for and devoted to that purpose in recognition of the company's duty to the public.

If it has been the settled policy to include such properties, then the investor, being relieved from risk and loss of interest in such investments, might in fairness well feel that the public had acquired such rights as would warrant his accepting a lower interest return, or its equivalent, on the value of such property after it finally comes into actual use than otherwise. In other words, actual cost would then have greater weight in determining value for rate-fixing purposes than the cost of an equivalent property.

If, on the other hand, it has been the established policy to exclude all property not actually employed for the supplying of water in determining value for rate-fixing purposes, thus compelling the water company in the discharge of its duty to carry such properties, it may be for years, at its own risk, then surely this original cost has much less weight in determining their value when they do come into actual use, — unless, indeed, cost be made to include also the losses of interest due to their retention, — and the present cost of other equivalent properties becomes of correspondingly greater importance in determining value.

It therefore logically appears that lands and water rights in general, which of necessity are in the main secured and held long periods in advance of their actual use, should, in the determination of their values after they have been brought into use, have considered their cost inclusive of loss of interest, and also the cost of acquiring a substitutional equivalent. The latter should establish the maximum and the former the minimum when below the latter, provided that the total valuation of the entire water-works property does not exceed the value of the service rendered. Should original cost with interest prove greater than a substitutional equivalent, it demonstrates imprudence for which the consumer should not be held responsible.

The Estimated Cost of the Reduplication of the Existing Structural Works and Its Relation to Cost and Value of the Existing Plant.

Previously herein have been pointed out the grave objections to adopting the theory suggested by this heading as the sole or even paramount consideration in the determination of value of existing structures when they are sought to be valued simply as structures separately and independent of their relation to the system as a whole.

Nevertheless, it is proper to make such inquiry even though the actual cost of the existing structures may be known with certainty, for the answers will usually be serviceable in determining the degree of prudence and economic skill which has been exercised in the construction of the existing works. In other words, the answer to the query goes rather to the question of prudence in the expenditures actually made than to the value of the structural works in question. This is particularly true where the rate-fixing authorities have pursued the policy of not allowing a revenue sufficient for safeguarding the actual investment in structures against subsequent falling prices and corresponding lesser cost of their reduplication at a later date.

Works of the magnitude here considered never are and cannot be constructed as of any particular date or any particular year. In determining, therefore, the probable cost of their reduplication, it is necessary to forecast the prices of materials and labor likely to prevail, at least during such period of time as would be necessary to carry out the assumed program. To make such forecast, one cannot usually do better than to judge the future by the past and assume as a basis the general average of conditions which have prevailed for a period of years.

The Estimated Cost of the Construction of Substitutional Works and Its Relation to Value of the Existing Plant.

The estimated cost of constructing independent substitutional works has, for reasons already fully set forth, little relation to the actual value of existing structures, save as such studies may throw light upon the question of the wisdom of the adopted plans after which the works have been built.

Unless such estimates can prove the existence of gross and inexcusable error in the adopted plans, they are not entitled to great weight in determining the value of existing structures.

In determining the value, however, of any combination of real estate and water rights which have together been made a source of water supply for which there exists a demand, the estimated cost of creating an equivalent from the next most available source becomes at least one measure within limits of the present value of the properties and rights already acquired and in use.

This proposition rests upon the theory that since such enhancement of value due to general community growth and prosperity, to which a water company so largely contributes,

is, in the case of individuals or private enterprises, always regarded as legitimate gain, there seems absolutely no reason why the properties of a water corporation devoted by process of law to the public use for no more than a fair annual return upon its value should not share in such enhancement.

The writer has pointed out that this is entitled to special weight in determining the value of water-producing properties when companies are compelled to carry them at their own risk and expense until such time as they are actually required for use.

Appreciation of Real Estate and Water-Producing Properties and Its Relation to Value.

It seems clear that any determination of present value, if cost be used as the starting point, should be influenced by the appreciation, if any, that has taken place in real estate, water rights, and such like properties since their acquisition by the owners of the works.

It not infrequently happens, especially in the semi-arid sections of the country, that water rights and privileges and real estate so situated as to afford unusual natural opportunities for run-off and storage facilities of an exceptional character, though secured at comparatively small expense, through increased demand due to increase in population, become in time of greatly increased value.

Inasmuch as such enhancement of values is always regarded in the case of private enterprise as legitimate gain, and particularly since general prosperity which creates such enhancement is as largely fostered by a system of water works as by any other agency, there seems no valid reason why such increase of values above original cost should not accrue within limits to the advantage of the water company.

The actual determination of the present value of such assets must, of course, take into account the general scheme of which they form integral parts and the final result as a whole to which they contribute.

No piece of property, however difficult it be to find a satisfactory measure of its value, can be counted as worth less than the cost of other as favorably situated tracts.

If this principle is applied to the combination of properties which, because of their having been brought together, have made possible the delivery for possibly all time of a suitable volume of potable water, then logically the amount of increase in value of such property or its present value would be sought in the

cost of developing or otherwise obtaining an equally abundant and equally marketable supply from the next most available source.

This, then, is the justification for using the probable cost of a substitutional equivalent as at least strongly indicative of value.

This method will usually have its chief application and will most affect the final result in the case of those properties used for creating and safeguarding the courses of water supply as distinct from the distributing system, in those regions of the West where the water supply is the great problem.

On the other hand, where the community has at hand inexhaustible sources of supply free to any one at the cost of taking, water rights may have no value, and no increase in their value then becomes ordinarily possible.

Has the Franchise any Value?

The answer to this question depends upon what is meant by franchise. If a concern is actually earning revenue in excess of an amount sufficient to meet all costs of production, including a proper return upon the value of the property employed, it has become a very common practice to credit such surplus earnings to franchise. It cannot be denied that under such conditions, by whatever name it may be called, this ability to earn a large surplus, when it may be exercised, constitutes an important element of value.

It appears, however, that the creation of any earning power directly attributable to franchise under this definition, and the consequent creation for it of real value where it has cost nothing, presupposes the entire absence of regulation of rates on the part of government for the purpose of securing water service at no greater cost to the consumers than is consistent with fairness to the water company. In other words, franchise, if it has cost nothing, is not necessarily an element of value upon which any revenue need in fairness be allowed by rate-fixing authorities. Indeed, the very purpose of the law apparently is to prevent such excess earnings as are here assumed to give value to the franchise.

If there are no legal restrictions, and a water company is allowed to collect such rates as seem to it alone expedient, it may easily be imagined that its earnings might in many cases be greatly in excess of what would net it a very reasonable or

even liberal return upon the otherwise value of its property, no matter by what rational method such value were determined.

Again, when water companies have by wise foresight and prudent expenditures acquired properties, such, for instance, as lands and water rights, which by reason of their special adaptation to their purpose cannot be dispensed with without securing other properties productive of equivalent results at a cost materially in excess of the investments actually made, such enhancements of value have sometimes been credited to franchise.

This element of value has already been pointed out to be a very real asset; but it stands in a class by itself. To term it franchise value seems a misnomer since it represents real value wholly independent of the franchise.

Again, the fact that a property possessed of and actually doing a large business capable of affording a sufficient revenue is worth more than a similar property without such business has sometimes been termed franchise value.

This, too, while doubtless a real asset, is better classed as "established business," and will later be again referred to.

The writer is, therefore, of the opinion that the first beforementioned view of what constitutes franchise value is the correct one; that every other element of real value is more properly classified elsewhere, and that under wisely drawn legal provision for the regulation of rates, no value need attach to franchise either for purposes of taxation or revenue.

Does any Special Value Attach to the Fact that a Company has an Established Business?

Mention has already been made of this element of value. It has been pointed out that a system of works already possessed of sufficient business to make the property a profitable investment is worth more than a similar property without a revenue.

That an established business constitutes a very real asset would seem to be beyond dispute, but the money measure of its value is so difficult of determination that it has at times compelled resort to mere arbitrary opinion. Such a procedure is always to be avoided if a logical standard can be found.

It does not appear that such a standard is wanting where proper accounting has been employed, and its reasonableness lies in the fact that it is rooted in the necessities of water-works construction and growth as demonstrated by general experience.

This measure is found in the actual cost of establishing the business as ascertained by the losses during the early history

of the plant arising from the want of a sufficient revenue to pay at least current rates of interest on the necessary investments. Reference has already been made briefly to this subject, but it is worthy a little further amplification here, even at the risk of some repetition.

The building of water works suited to prevailing needs, with liberal allowance for future increase, is a work of necessity for any modern city, a work which, especially in the regions of sparse rainfall, must, after the first nucleus is formed, precede rather than follow growth in population.

A suitable water service must be obtained regardless of the magnitude of the necessary cost.

Because of these facts it almost invariably happens where local conditions render necessary heavy initial capital outlays, that to some extent the future must be discounted in the early financing of the enterprise. In other words, the limited number of rate payers makes it impossible for the enterprise to pay adequate returns on the investment until the population and business industry, increasing under the stimulus of an abundant water supply and other causes, make possible an adequate revenue.

What is to be the return for this unavoidable additional source of expenditure in the establishing of a sufficient business? Its result is the creation of this asset of "established business," and the attendant expense is an actual measure of what it has cost to create it by the only means by which such an element of water-works value can be created. Cost is, therefore, a rational measure of the value of this element, "established business."

The Value of the Service Rendered to the Public and the Limitations It Imposes upon Value.

The value of an established water-works property, no matter how great may have been its cost, nor how great a sum would be required to secure a substitutional equivalent, cannot in the final analysis be more for rate-fixing purposes than the capitalization of its greatest possible net earnings without restriction as to charges. In other words, the worth of the service to the consumers will always fix a maximum beyond which no theory of value, however plausible it may appear, can be followed.

What is the worth of the service to the consumers, and how

may it limit the possible revenue and thus limit the value of the water-works property?

First.— The service is not worth more to any consumer than it will cost him individually to secure an equivalent by pumping out of a well or from some other available source, if there be any; for if the rate charged exceeds this amount, many will utilize such source in preference, with corresponding loss of revenue to the water company. The same holds good for all consumers collectively, save that in such capacity they may be expected to regard the public welfare as well as that of the individual.

Second.— If there is no other possible substitutional supply, thus placing the water company in the position of having an absolute monopoly, still the value of the service rendered cannot be worth more than the consumer can afford to pay interest upon, without impairing general prosperity and checking municipal growth.

To illustrate the above truths: If a water company were wholly unrestricted by any governmental agency in determining the amount of its charges, it would be folly for it to impose rates so high, no matter how great its necessary investment, as to invite destructive competition; and if no competition were possible, it would be just as foolish for it to injure its present as well as its future business by imposing rates so high as to check general prosperity and retard municipal growth. A wise policy and the one calculated to derive in the long run the greatest possible returns would always seek to keep well within these limits, and keeping within these limits, the property could not for rate fixing have a greater value than the revenue then received could support.

If the investment of the water company should prove in the long run greater than the value thus justified by the permissible rates, the loss is chargeable to bad judgment on the part of the investors and they should not be heard to complain.

When one attempts an inquiry as to the value of the service rendered in the specific case of any city, he finds himself, however, without any standards of exact comparison. Water rates charged in different places are indicative of general practice, but each is determined by widely varying local conditions, and none may answer the question directly as to what is the maximum revenue that those local conditions would if necessary warrant. If, however, the rates in question are ascertained by comparison to be materially less than have been successfully imposed with-

out evil results in other cities of comparable wealth and general prosperity, it may be inferred that the application of similar rates would in the case in hand be a safe procedure.

Again, if property improved and unimproved is enhancing rapidly in value, it is evident that the imposing, if need be, upon it of an increased cost of water service would accomplish no worse result than to divide the so-called "unearned increment" due to general increase in population in some proportion between water works and real property.

This phase of the subject, then, deals with the total gross revenues which the company should be allowed to collect, wholly regardless of the magnitude of its actual investment. Its application, therefore, requires the study of general taxation as well as that imposed upon the company, the amount of revenue paid the company in compensation for public service, the cost to the company of operating and maintaining its works, the provision, if any, which should be made annually for liquidating investments in perishable structures or others which ultimately require abandonment, and the rate of interest which the property is entitled to earn over and above all expenses.

While only general conclusions can be drawn from so complex a study, they can, with the exercise of care, be made sufficient to establish the limitations sought with a degree of accuracy suited to the demands of substantial justice.

Final Summarizing of Conclusions and Determination of Present Value.

Having considered the various hereinbefore enumerated factors likely to influence the value of any property under consideration, and having summarized the results, it will remain to determine the varying degrees of importance and weight to attach to each, and to decide in view of all the attendant circumstances what the amount is upon which the water company is entitled to receive a suitable return.

As has been stated at the beginning of this paper, this final solution can never be reduced to a mathematical formula applicable to all cases. The before-suggested inquiry will have established approximate limitations both as to maximum and minimum, but there will even then usually be found remaining quite a wide intervening field for the exercise of individual discretion.

That the final result will so largely depend upon the personal equation does not of necessity detract from its worth. It

only shows the greatness of the problem which requires for its solution the exercise of faculties higher than the application of mere formulæ and mere routine, faculties which are rooted in laborious thought, in ripe experience, in moral worth.

Justice in dealing with such highly abstract questions calls only for the best that can be had, and nothing less; and the best will always be found sufficient for its ends, for this it is which determines our highest natural sense of justice itself, upon which all law must finally rest.

A METHOD OF FILING NOTES, SKETCHES AND CLIPPINGS.

By James C. Bennett, Member of the Technical Society of the Pacific Coast.

[Read before the Autumnal Meeting of the Society, December 15, 1905.]

So many descriptions have from time to time been presented of ways and means for filing notes and memoranda, that one almost feels it advisable to introduce such a topic with an apology. In support of this further contribution to the subject, however, it may be said that the writer has investigated most of those methods that have appeared for several years past, and has tried a number of them himself.

In selecting a method of preserving data, there are three principal factors that should govern the selection, their relative importance being in the order named. First, usefulness; this refers to the ease with which reference may be made to the files in the future. Second, convenience in filing the data. Third, expense.

The method that has been finally adopted by the writer as best suited to his requirements consists of one or more loose-leaf books with leaves of the standard 8½ in. by 11 in. bond letter paper, and suitable covers, together with a card index. As the notes are filed they are divided roughly into the various classifications, such as Electric Power, Construction, Materials, etc., according to the individual needs of the engineer. These subdivisions are then provided with a designating letter or symbol, and the leaves numbered consecutively as used, from 1 up to 100, more or less according to the amount of matter to be filed, and according to the thickness of the book that is desired. As the notes are obtained, they are either pasted on to the leaves or copied directly on to them, as the case may be, and the article is then indexed in the card catalogue under the one or more headings for which one is likely to look in the future. There is no attempt made at subdividing the cards, as this only leads to confusion. The most satisfactory way is to place the cards alphabetically only, using the regular guides that usually accompany such sets. The 3-in. by 5-in. card has proved to be the most suitable size.

By way of illustration of the working of the plan, let us wish to look up the cost of the installation of a certain blower and

engine that were placed some time since. We may find the item under "Blower," "Engine," or the name of the firm for whom the work was done. On each of these cards we may find several other items, but there will be no difficulty in identifying the one desired, as there is sufficient description to clearly indicate it. At the right of the line we find the index, "32–C," and, taking the book which has a large letter "C" on its back, we turn to page 32, where we find the information sought, it may be as a summary or as a description with sketches accompanying it. The record may take up four or five pages, each of which is marked "32–C–a," "32–C–b," and so on; thus in case any of the leaves should be misplaced it is not difficult to identify them and restore them to their proper places. This also admits of future additions to the original, should later developments render it desirable, by using the next sub-index on the newly added sheet, without in any way disarranging the leaves already in place.

Some question may arise in the minds of some as to the reason for dividing the data up into the several headings, and, in answer to this possible question, it is done only to facilitate the handling, as it saves looking over so many pages; in short, it is in the nature of dividing a lengthy subject into volumes. Of course there are many notes that come to one's notice which it is difficult to classify clearly. In such cases, there is no harm done, or future inconvenience occasioned, if they are not strictly and correctly placed, as the different volumes are, as has just been stated, for convenience in handling and not necessarily for strict subdivision. Hence, in the illustration just cited, it would have been fully as easy to find the memoranda on blower installation had it been placed in the volume on steam power, and accordingly indexed.

The standard letter size was adopted because of its convenient size for handling and because it affords sufficient space for quite copious notes. Further, by using such paper and size, charts and tables may be made directly on the leaves, and, if it is desired, blue prints may be taken at any future time. In the writer's files there are also several such tables on tracing cloth, cut to proper size, and some that are folded once, which, in those particular instances, could be done without obliterating any of the important matter. Again, it sometimes happens that there are several pages of printed matter devoted entirely to a particular subject which are smaller than the standard size, or can be so trimmed. In such cases it has seemed best to place

the entire article on one sheet, thus forming a small book or pamphlet within the main volume and having but the one principal number.

Probably the most important point of this method of filing is the selection of a suitable cover and binder for the books. The writer has tried some six or eight different covers for this purpose, and as a result of the experiments is convinced that the proper selection of a cover is the one thing that really renders the notes truly useful or merely ornamental. The two principal requisites of the cover are, the ability to remove a leaf occasionally without disturbing the remainder of the book, and the ability to insert additional matter without disarranging the pages which follow. After having tried a number of the binders, one, known as the Irving Pitt Price List Cover, was found to approach most nearly the fulfillment of the important conditions that have been cited. This cover is provided with snap rings which are divided midway between the covers, so that it is an easy and simple matter to remove or insert a leaf at almost any part of the book without disarranging any of the preceding or following pages.

The method which has just been described cannot claim for itself the lowest first cost, but, as indicated at the beginning of this description, the cost is, in the writer's mind, the third of the most important requisites of an efficient means of filing data. Thus the method under consideration conforms fairly closely with the conditions imposed, namely, usefulness, convenience in filing and expense.

PROBLEMS THAT CONFRONT ENGINEERING AND KINDRED INDUSTRIES ON THE PACIFIC COAST.

By George W. Dickie, President of the Technical Society of the Pacific Coast.

[Read before the Pacific Coast Engineering Congress (Lewis and Clark Exposition), at Portland, Ore., June 29, 1905.

The physical problems that have to be encountered by the engineer in his efforts to bring the vast territory known as the Pacific Coast into the best productive condition, and to render it a desirable and comfortable place to live in, are peculiar to this side of the continent. The conformation of the face of the country, the character of the rock strata, the extreme condition of wetness in one locality and a similar condition of dryness in another locality, with a sparse population that limits the possible expenditure, are problems that our engineers have struggled with during the last fifty years, and they will be with us for fifty years to come. These problems can be safely left with the engineers now battling with them and to those who will follow them in the fields now occupied and in the new fields of enterprise that time and conditions are continually opening up. The problems I wish to bring before you at this time are not those of a physical character but are those that may be said to come within the department of economics. By engineering and kindred industries I mean all establishments whose business involves constructive engineering in all its branches; this includes all manufactures in metals although not strictly engineering. In all this class of industrial products labor forms a large percentage of the total cost of production; and, in order to reduce costs to the lowest possible point, manufacturing establishments must confine themselves to a certain line of output, perfect that line both in design and in method of production, having special tools for each stage in the process of manufacture. To make this possible a large market is necessary for each kind of product. These conditions, so necessary to successful production of the numerous and varied mechanical devices required to carry on our modern civilization, are not yet present on the Pacific coast; gradually they will come with population, but we are yet very far from the conditions that will make industrial engineering an assured success amongst us. In many respects the general

engineering establishment on the Pacific coast was better off, as regards the certainty of business, thirty years ago than it is to-day. At that time the agent or representative of the manufacturer of machinery in the more densely populated parts of the country had not yet established himself on the Pacific coast, and whatever machinery was required here for mines, saw mills, flour mills, steamboats, street railroads, etc., was built to order by some local engineering establishment on the best terms his customer could make with him, and usually for some special type of machinery suited to the requirements of the case. Thus in some cases the best type of machinery for certain purposes originated on this coast, and some notable examples of bold engineering were carried out successfully that engineers in more settled communities would not have dared to undertake. Yet this very originality of engineering conception rendered the establishments that carried out such projects quite unfit to undertake the manufacture of machinery on economical lines. As soon, however, as the amount of machinery required on the Pacific coast was sufficient in volume to attract the notice of manufacturers of special types of mechanism for various purposes, representative agencies were established in the centers nearest to where the bulk of such machinery was required, and the representative, representing, as he usually does, many manufacturing establishments and being well furnished with plans, illustrations, and specifications of the machinery he can furnish, is in a much better position to secure the general run of work of this character than the local establishments that have nothing that they manufacture to meet any general demand, but build some special machines to meet as far as they can the special needs of their customers; and herein lie the difference and the problem that the local establishment must solve or fail to reach permanent success. The agent representing several large manufacturing establishments whose markets cover the needs of the whole country and who make some special standard type of machinery well designed to meet the general requirements, has only to persuade his prospective customer that generally the machine he offers is the best adapted to the purpose in view and that it will be for his interest to modify any special condition in his case in order to use the standard type; and this reasoning promising, as it usually does, a saving in outlay, has a pretty good chance to succeed. The local engineering establishment has but one chance, and that is to persuade its prospective customer that the special conditions of his case cannot be

ignored or changed without risking the success of his enterprise, that the machine that will entirely meet all his requirements successfully cannot be secured from the stock of any manufacturing establishment, but must be specially designed to meet his special conditions, and that though it costs considerably more, yet in the long run it will prove the best for him. Though the reasoning of the local engineer is not always true, for he tries to magnify the one condition as much as possible, it is still a fact that the prospective customer seldom gives proper value to the condition demanding special treatment, but takes the easiest course, the one requiring no study of conditions, examination into special plans, etc., and is inclined to accept the standard machine that can be delivered quickly and which he can actually see before he buys. Thus the local engineer is outdone by the local representative of a distant manufacturer, and the business that should support local establishments, increasing our wealth and population, goes away to enrich other communities. Here is a problem for both the engineer and the capitalist. The engineering business on the Pacific coast does not suffer for lack of ability on the part of the managing engineers, but rather because of too much brain.

If a Pacific coast engineering establishment has to compete with an eastern establishment on an engineering proposition instead of a manufacturing proposition, even though freight and wages be heavily against the Pacific coast engineer, his ability to handle new problems as they come to him will enable him to practically hold his own in the fight. This has been very forcibly illustrated in the building of naval vessels on the Pacific coast. One concern has kept on building war ships at San Francisco, and has evidently done as good work and with as good result in the way of profit as any of the eastern establishments with which it has been in competition. This goes far to prove that for work that is not simply repetition the Pacific coast engineer can and does hold his own against work of a similar character produced on the Atlantic coast.

How, then, is he going to adapt himself and his establishment so as to keep that establishment going with full power, with a large part of his work of the character that forms the standard work turned out by the eastern manufacturing establishments?

He cannot hope to extend his market beyond the limits of the Pacific coast under the conditions in force here, and on that account cannot manufacture in the same sense that his eastern competitor does. He has some advantages, however, that count

in his favor. The cost of maintaining agencies, and commissions on selling the standard manufactured machinery, is probably not less than 25 per cent. of the total cost, and this should help the local engineering establishment; but as things are usually managed this advantage is not nearly enough for the local concern and may be entirely eliminated by the manufacturer whose market extending over the whole country gives him the chance to sell cheap at any place where the local establishment tries to sell the same class of machinery.

The prospect, in California especially, has brightened somewhat of late, owing to the discovery of great subterranean stores of liquid fuel, which generally means a saving of 50 per cent. in the fuel bills of an engineering establishment; besides, it makes enterprises such as electric generation for lighting and power purposes possible that would not otherwise have been attempted, thus creating new fields for the engineering talent and the constructive ability of the country to work in. A good deal of this new field, that of the cheap generation of electricity either through the burning of liquid fuel that comes from below or the falling of a purer liquid from the mountains, is, I am sorry to say, not being cultivated by the local engineering works as it might be. I believe there is a splendid opportunity at the present time to establish somewhere on the Pacific coast a great electrical establishment which would turn out complete electrical generating plants operated either by steam engines, water motors, or steam turbines. The field for this class of work on the Pacific coast is a large one now and will grow steadily until it becomes one of our greatest industries. I have had some experience in the building of electrical generating plants on the Pacific coast, the work being done in connection with a much larger output of general engineering work; and under these conditions I found it quite possible to build at a cost never greater than the selling price of similar work manufactured in eastern establishments as standard work. This leads me to believe that an establishment devoting its undivided attention to supplying the needs of the Pacific coast in electrical engineering could build up a splendid and profitable business, combining well designed generators and equally well designed engines or water wheels, and taking in also all the engineering accessories that form part of any completed electrical generating plant. The principal factor in such an enterprise would be the cost of labor. As this item will be between 50 per cent. and 60 per cent. of the total cost of production, its regulation will always be of the utmost importance.

The rate of wages by the present system of compensating labor will, I think, be always higher on the Pacific coast than it is elsewhere. Perhaps no other reason can be given for this condition than that it is so and is likely to be so indefinitely; but while the rate of wages is higher here, I do not think that the amount of wages paid for a given result need or should be higher here than it is elsewhere. I have for some years back been advocating a system of compensation for the labor in such establishments, whereby the men as a whole who are to do the work should contract with the owners of the establishment in which they work for the whole labor involved in producing a certain industrial result; this would enable the workmen to decide whether they could afford to do the labor part involved in producing certain kinds of machinery for such an amount as would make it possible for the establishment in which they work to undertake the production of such machinery. There are four factors that go to make up all estimates of cost in the class of industrial products we are now considering; these are:

First. — The prime cost of all the materials required for the proposed work to be done.

Second. — The actual cost of all labor necessary to convert the materials into the finished result ready for delivery to or acceptance by the customer for whom the work is done.

Third. — The proportion of the general expense account chargeable on such estimate.

Fourth. — Profit.

No work can be properly entered into by any industrial establishment, either as a contract or as something to be manufactured and sold as a finished product, without a careful estimate being made of all the items forming these four factors in the completed cost.

The estimator, if his work is to be a safe guide for the firm or company that he represents, must have correct information as to the amount of and the cost of all materials to be used in carrying out any proposed contract or the manufacture of any product for the market; this item is within the capacity of a competent man to have correct, so there need be no doubt about the first factor in the completed cost. The third item in the cost is the difference between the net and overhead costs, providing for the proper share of the general expense account. There is some difference of opinion amongst those who manage engineering establishments as to what should form general expense. I have always held that all charges of every nature that cannot be

charged directly to the individual job should be charged to this account. This would include the cost of general management, all foremen in charge of more than one job, all handling of material until it is charged to some particular work, all fuel and water bills, the whole office force except draftsmen that are charged directly to the job they are working on, taxes, traveling and advertising expenses, repairs and depreciation. If, for instance, an estimate were being made the approximate amount of which was $1 000 000, and the total amount of work done the previous year was $5 000 000, and the general expense account including all items not chargeable direct to a specific job for the year was $500 000, then the item for general expense in an estimate amounting to $1 000 000 would be $100 000. There is no reason why this important factor in the estimate should not be correct, and to keep it as low as possible and still be correct has an important bearing on the success of the business in question; the larger the output in proportion to the general expense the less the prime cost of the article produced.

The second item in the cost, the actual cost of all labor necessary to convert the material into the finished result ready for delivery to or acceptance by the customer, is the uncertain factor that brings the element of speculation into the estimate; and while it forms the largest single item of the estimate, the estimator can only approximate its cost from past experience; what the ultimate cost of the labor will be depends largely upon the relation between his company and the men who are to do the work.

The variations in the cost of labor on the same amount of work done at different times, resulting from different men and different conditions, is often sufficient to wipe out several times over the estimated profit on a contract; and I have often thought that if it were possible to make the labor item in our estimate a sure thing it would bring new life and vigor into engineering industries over the Pacific coast. There is a certain amount available for the compensation of labor in the estimated cost of the product in any industry, and that amount cannot be exceeded under a given condition of market. If the fourth item, that of profit, were 10 per cent., an addition of 20 per cent. to the labor item would completely wipe out profit. This variation of 20 per cent. in the cost of the labor item is not an unusual occurrence under the present system of compensation for labor.

In estimates involving many trades and large numbers of men, even under ordinary peaceful conditions, large allowances

must be made for incompetent men and unwilling hands that wait for time to move on to pay day and have no interest in what has been produced for the pay they receive. My experience has led me to the conclusion that a desire to do the very best they could by all hands every day would, in engineering establishments that pay their men for the time they are at work, practically double the labor result. How can this desire to work be excited in the workman? I have carefully studied several methods in use to encourage this desire to work, at industrial establishments both in this country and in Europe, having for their object the compensation of the workmen in accordance with the work produced without the objectionable feature of piece work. Piece work and most of the premium plans deal with the product of the individual man, and, besides raising comparisons between the men themselves which are odious here as elsewhere, can only be applied to such parts of the work as can be readily separated from the general work being done, and in large establishments cover only a small portion of the work. My experience, combined with a careful study of this subject, has forced me to the conclusion that the only way to get the best result out of all the men employed in a large industrial establishment is to combine them all by mutual interest in bringing about the best possible industrial result, and into that combination the employer must also bring his interests. The working man must first be made to understand that the establishment in which he works must be run at a profit or it will soon cease to run at all. The possible profit is a difficult thing to get the men to understand; many workmen, gathering their information from the wild statements made by labor leaders and a certain class of newspapers, have very exaggerated notions of the profits made in engineering industries. I had occasion some time ago to speak to a number of workmen bent on forcing very hard conditions on their employers, and the question of profits was brought up during the discussion, showing that their ideas of what it was possible for their employer to do, and yet have something left, were quite remarkable; nor could any impression be made upon them by the statement that in eighteen years their employers had paid out in wages \$28 000 000 and that during the same time the stockholders had been paid \$1 300 000 in profits, or less than 5 per cent. of the wages paid. This would have given each workman one and one-half cents more wages per hour and the stockholders nothing, yet these same men, if they had all worked their best, might have readily doubled the result and thereby

increased materially both pay and profit. In the attempt to solve the problems involved in labor costs on the Pacific coast the main thing that both the employer and the employed must accept as the foundation for any scheme that is to permanently bring about proper and natural relations between them and give hope in regard to our industries, is justice; without that nothing can be done. The one side must have perfect confidence in the justice of the other. If this attitude can be assumed and maintained all other difficulties can be overcome. Most of my thinking combined with some action on this problem has been in connection with engineering industries, and I would like to state to you, as far as I can in words, how I would propose to solve the problems in the cost of labor. I have stated that in all estimates labor is or should be treated as an independent factor, and it is the most difficult of all the factors entering into an estimate to determine. What it should be to meet the market value of the work produced is within the power of the experienced estimator to decide; but what it will be depends entirely on how the men that are to do the work feel about it. I have found out a curious fact about this question of labor values; that all the intelligent workmen whom I consult with about it set a much lower value on the labor required to produce a given result than my experience tells me is necessary. They instinctively think of what a man could do if he tried, while I have been forced to figure on what he generally does; and thus, what under ordinary circumstances an unwilling man can be persuaded to do has become the measure of the value of labor in the estimates that are regularly made in engineering works where the men are paid for time instead of for work. In engineering estimates the labor item will be from 40 per cent. to 60 per cent. of the total amount. Very few workmen believe this; in fact I have generally found them under the impression that the profit was from 40 per cent. to 60 per cent. An average proportion for general machinery estimates would be:

Labor	40	per cent.
Material	40	,,
General expenses	12	,,
Possible profit	8	,,

With this proportion, which may be taken as roughly correct, an increase of 20 per cent. in the cost of labor would completely wipe out the item of profit.

Suppose, then, that our engineering establishment agreed with all the men employed in the works that the amount set

aside for labor in any estimate should be accepted by the men employed as a whole as the compensation they should receive for performing all the labor required to complete the work represented by that estimate. All the men employed in that case would have to be represented by a committee of themselves, say one from each department of the works, who would go over the estimate of labor with the representative of the works who made the estimate, and accept if satisfactory on behalf of the men they represent. This might be done before the tendering for the work, so that the workmen themselves would be tendering for the labor part of the proposed contract. The question might be raised here as to the ability of those representing the men to determine as to the correctness of any estimate for labor, whether the employer has all the skill and experience necessary to make his estimate of labor, while the representatives of the men do not, as a rule, possess this skill, and whether the men would therefore be at the mercy of the employer. There need be no fear of this difficulty, as the men are not likely to appoint representatives who are not thoroughly competent to watch their interests; in fact, as already stated, the men are apt to place a lower estimate on the value of labor than the employer. The employer, as at present, would ultimately have to stand the chance of possible loss, but that chance would be very much less than it is at present, as the possible gain by the workmen would be an incentive to every one to do his best.

Under such an arrangement I would propose to engage all the men just as they are employed under the present system, the foreman rating every man at what he considered him worth per day; or, to meet the altruistic ideas now prevailing among the trades union men, a uniform rate could be decided upon for all the tradesmen; rates also would be fixed for apprentices learning trades, and rates for laborers. Each man's or boy's rating would be posted up in the department in which he worked, and his fellow workmen through their committee should have the right to have this rate reduced if they found that the work he turned out was not equal to his rating. All wages would be paid as at present according to the rating. The full amount for which the men had contracted to do the whole labor on any job would be placed to the credit of labor on that job, and the wages paid out on that job would be charged against that account. As each job or contract was finished, the unexpended amount on that particular job or contract, if any, would then be credited to the labor surplus account. If on any job or contract the wages paid

should be more than the amount accepted for labor, the difference would be charged to the labor surplus account. At the end of each year the amount that had accumulated in the labor surplus account would be available as a dividend on labor, and whatever percentage it formed of the total amount paid for labor during the year would be the percentage each man would receive on the amount he had earned during the year.

This enables each workman to participate in the profit of the labor part on all work done in the establishment, whether he was a long time or a short time employed during the year, and without any reference to the particular job he may have worked on; so that no matter what he may be doing or in what capacity he works, how he does that work will either swell or diminish the general dividend, and every man will see to it that his fellow workman does not reduce his dividend if any instruction on his part will prevent it.

I believe the time has come when the item of labor must be dealt with by methods different from the present ones. It cannot be considered as an article that can be bought by any time-measuring arrangement. The time has come when it can be contracted with; its hopes must be taken into account; it must have something to strive for or it will not strive at all. I believe that the difference in result between the work of earnest workmen who try to do the best they can and whose recompense is measured by what they accomplish, and the indifferent labor that is forced out of men by constant watching and urging during a certain number of hours, is so great that it would practically compensate for the difference between the cost of production in the manufacturing establishments of the Atlantic coast and the cost of production under existing conditions on the Pacific coast. I fully understand that such a system of compensation to workmen as I have outlined presents difficulties of a special character in every kind of business. I have studied it very carefully in its application to an engineering business and have reached the conclusion that some such plan as I propose will be ultimately accepted by both employer and employed as the only solution of the labor problem as it affects industrial engineering. Courage and honesty combined with the right kind of skill on the part of those managing such concerns would, if patiently applied, result in such benefits to workmen and to those with whom they work as would save many an industry on this coast which under the present unjust methods of dealing with labor problems has nothing before it but impending ruin. I have dwelt thus long on

the labor problem as it affects the possibility of constructing here on this coast the great bulk of the machinery required in the development of our resources, because it is, after all, the great and only hard problem that confronts us. Give labor the place that its importance demands in the councils of men. It is 40 per cent. of the problem of operating successfully any engineering establishment and should have its say in regard to that 40 per cent. if admitted to council. Labor unions would soon lose themselves in labor associations represented by directors of their own choosing, who would be a 40 per cent. factor in every estimate that was made and who would be able to give and take with the other 60 per cent. in order to meet the conditions of market values. If the manager of an engineering establishment could meet the representatives of the workmen when making up his estimate for work to be done, and settle with them the cost of the labor part of the estimate, just as he meets the steel manufacturer and settles with him the cost of the part that he is to furnish, then mutual concessions that might be necessary in order to prevent the work from going elsewhere could be made without the feeling that either party was trying to get an advantage over the other.

Our universities are training large numbers of young men in the various branches of engineering, and out of our common schools are flocking thousands of youths eager to find places in the mechanical crafts, probably one hundred for each one that can get a chance, because one commission agent can sell as much finished work as will keep 500 hands at work in some far-off establishment, while a corresponding number of hands are idle here. The Pacific coast will make slow progress in the mechanical arts until conditions are such as will enable us to do much more of our own work than we are now doing. What is usually termed "business management" is also a factor in the success of any engineering industrial enterprise. The ability to make something well and economically must be combined with the ability to sell it to the best advantage and in the nearest market; these two qualities are not often found in the same individual in their highest development. Still, a good engineer should also be a good business man. Both of these faculties need common sense and the habit of thinking clearly, backed by an educated judgment. Of these two requisites, however, the engineering business is most dependent upon the ability to make the proper thing for the work in hand at a price that will enable it to enter the market and compete successfully. In other indus-

tries the business faculty is the dominating factor in success. In some industries the cost of manufacture is but a small percentage of the cost of the finished product; in such cases business management in buying the raw material at the one end and in selling the finished product at the other end of the completed transaction is of vital importance. Take the sugar refining industry, that may be said to have succeeded on the Pacific coast. The cost of refining sugar in a first-class modern refinery is less than one eighth of a cent per pound, while the fluctuations in the price of raw sugar and of the refined product may be many times the total cost of refining in the course of a year or two. In such cases success depends chiefly on the business management; but in the engineering industries the purchased raw material does not cost more than about 40 per cent. of the value of the finished product, hence the importance of shop economy where the other 60 per cent. is expended. The problem for the engineer to solve is, How can I, on the Pacific coast, with all the elements that go to make up that 60 per cent. costing more than anywhere else, bring about a final result such as will enable me to sell my product at a price that will not be greater than the product of another establishment so situated that the elements that go to make their 60 per cent. cost less than they do here? It is just such industries, the problems connected with which are so hard to settle, that are of most importance in the development and building up of the Pacific coast. The volume of business done is not always a true measure of the prosperity of a state. The kind of business done is often of more importance than the amount. An agent selling $100 000 worth of machinery on the Pacific coast and receiving 10 per cent. commission can only distribute $10,000 in the community out of the $100 000 spent, while if the same machinery had been made here, $60 000 would have been distributed in the community out of the $100 000 spent. Compare the business of sugar refining, already mentioned as having succeeded on the Pacific coast, with an engineering business which I will suppose to be also successful:

The refiner buys raw sugar to the extent of	$5 000 000
Cost of refining..	187 500
Total cost of product ready for the market	$5 187 500
The refiner sells this product at	6 687 500
Refiner's profit	$1 500 000

The refiner may take his profit anywhere and spend it, or he may reinvest it in the community and thus build up the state,

but the immediate distribution that takes place is only the $187 500, or the employment of about 235 men.

The engineer buys raw material to the extent of	$5 000 000
Expends in converting raw material into machinery	7 500 000
Total cost of product ready for the market	$12 500 000
The engineer sells this product at	13 500 000
Engineer's profit..............................	$1 000 000

The engineer may, like the refiner, take his profit anywhere and spend it, or he may invest it in the community and thus help to build up the state, but the immediate distribution that takes place is $7 500 000, or the employment of 9 375 men. This illustrates the difference between one kind of business and another as to their effect in building up a state; the unfortunate thing is that the business that produces the greatest difference in cost between the raw material and the finished product should be the most difficult to establish as permanent enterprise on the Pacific coast. If our labor costs could by any such plan as I have outlined be made to approximate what they are on the Atlantic coast, I believe that we could build here all the machinery, ships and other engineering products that the development of the Pacific coast requires. We should thus soon acquire a population that would give impetus to every enterprise and start this whole great territory on the high road to such a development as is not now dreamed of by the most advanced optimist amongst us.

ANNUAL ADDRESS.

By George W. Dickie, President of the Technical Society of the Pacific Coast.

[Delivered before the Technical Society of the Pacific Coast at the Autumnal Banquet, December 16, 1905.]

Having served you two terms of 2 years each as president, I cannot hope to be called again to that responsibility, but whatever my place in the Technical Society of the Pacific Coast may be, my interest in its welfare will never be other than it has been. It has been my honor to be connected with this society since its beginning and among the many societies with which I am connected, the Technical has and will, I trust, always have the first place in my heart.

In my inaugural address delivered before the society at its spring meeting, May 26, 1904, I gave you my impressions in a general way on the present and future of engineering on the Pacific coast. These impressions were expressed perhaps more fully in my address before the society at its spring meeting of this year, held in Portland, Ore. As I can add little or nothing to what I have already expressed as to the future prospects of engineering on this coast, perhaps it would not be out of place, in this retiring address, to look backward and reflect somewhat on the way by which we have come to this present. One does not need to have had a very brilliant career in engineering to find sufficient material, out of 36 years of active working experience, for an address that will, I think, interest the members of this society.

Beginning with the year 1869, when I came to San Francisco, a young man full of many ambitions that have never been realized, I was attracted here not from any knowledge of the place or its people, as I knew no one except the members of my immediate family with whom I came, but from a simple study of the map, acquiring a firm conviction that a city holding the position of San Francisco, with an open door to the Pacific Ocean and forming a part of a great progressive nation like the United States, could not fail to offer opportunities to a young man who had some confidence in himself and was not afraid of any amount of hard work that might lie between him and his ambition. The ambition was to be permitted to take an impor-

tant part in building the ships that would be required in developing the ocean commerce of such a city, for shipbuilding and marine engineering were what I thought I knew something about. In 1870 there was little or nothing doing in my specialty in San Francisco and I had been here some months without finding any opportunity to show what a clever chap I was. Reading the newspaper one day my eye caught an advertisement wanting a competent man to do the planning and erecting of a gas works plant; apply to the Risdon Iron Works. I looked hard at this advertisement; a competent man was wanted and I considered myself competent, but this man was wanted to plan and erect gas works and I knew little or nothing about gas works. Nature had endowed me with the faculty of using a little gas to help myself when such help was needed, but in this case I had not enough knowledge to warrant it expanding to the required bulk; this, however, was the only thing I had seen for any man to plan in the months I had been here. I wrote to the Risdon Iron Works saying that I would like to undertake the work for which they wanted a competent man, and asking for an appointment to see them about it. Having posted this letter, I went at once to the Mechanics' Library and sought out eagerly all they had on the subject of gas and spent the next 2 days steadily imbibing all the obtainable knowledge relative to the erection of gas works. The next day I was asked to call at the Risdon Iron Works; there I met Joseph Moore and started a friendship that lasted about 15 years; it should have lasted longer, but Mr. Moore thought that I had in some way done him an injury, and for the last 18 years of his life we were estranged. I desire to take this opportunity of saying that I do not think that Joseph Moore got the recognition on the Pacific coast that he deserved. He was a master mechanic of no mean ability, and his capacity for work in his best days was something enormous. He was the father of the riveted pipe as a great water conduit; he had also much to do with the early development of the special types of mining and ore-treating machinery that originated in California.

Mr. J. B. Haggin, then a trustee of the Risdon Iron Works, was to build an opposition gas works for San Francisco. The new works were to be located at the Potrero and the owners had intrusted the iron work to the Risdon Iron Works; hence the advertisement. Fresh from my study of the literature on gas works, I was able to impress Mr. Moore with my ability to take charge of anything that he had in that line and was engaged

for the work on which I was to begin next day. Mr. Moore had Mr. Haggin's engineer at the works to meet me, and I was introduced as a gas expert; this was fortunate indeed, as this engineer was quite innocent of any experience in the building of gas works and had not read the subject as I had; thus my reputation as an expert was safe. Plans of a newly-finished gas plant, in Philadelphia, were furnished as a guide and I found no difficulty in making what was wanted here. The works were built and put into operation without any trouble, while I was considered a pretty fair gas engineer.

About this time, when I was at the height of my fame as a gas engineer, the Pacific Mail Steamship Company concluded to fit one of their side-wheel steamers with a surface condenser. One day I heard their superintending engineer talking the matter over with Mr. Moore and wondering where they might get hold of some one who had had some experience in building surface condensers to take charge of this work; so as soon as Mr. Moore was alone I suggested to him that he put this matter in my hands and I would see it properly carried out.

"No," said he, "that would never do; you are a gas engineer, and this needs a marine engineer who knows all about surface condensers." As my ambition could not be reached by the way of gas engineering I had to confess the trick that I had played upon him in the matter of gas, and produced my letters of recommendation from engineers and shipbuilders in Scotland as evidence of my ability as a marine engineer, and finally succeeded in getting a start on the road that I have trudged along ever since. The surface condensers for the Pacific Mail Steamship Company were built and installed, the result proving very satisfactory. There were no compound engines in any of the boats on this coast at that time; in fact, I had built several of them here before they were introduced on the Atlantic. John Roach had the engines for the steamship *Granada* built in Glasgow and sent out as a pattern some years after the date I am now speaking of. About this time we secured the contract for the machinery of a coasting vessel named the *East Port*, to run between San Francisco and Coos Bay. The engine was of the single-cylinder type, 34 in. diameter by 34 in. stroke, surface condensing. I tried to have this changed to a compound engine, but the owners would not hear of it. The steam pressure was to be 70 lb. per sq. in., and instead of the fire-box type of boiler then prevalent I managed to get the consent of the owners to substitute a cylindrical Scotch 3-furnace boiler, 13 ft. diame-

ter and 11 ft. long. The inspection laws at that time limited the thickness of plate on which the fire impinged to 0.26 in., and the boiler inspector here at the time ruled that this requirement applied to the furnaces of my boiler and insisted that the furnace plates should not be over 0.26 in. in thickness; this forced me to put forged rings on the outside of the furnaces, about 10 in. apart, and with a water space between the furnace plates and the rings, the plate being secured to the rings by stay bolts about 10 in. apart. This boiler, while being built, was the object of much adverse criticism by boiler experts and its failure was confidently predicted. When it was standing on the dock waiting to be placed on board, the United States boiler inspector looked at it carefully for a while and then said to me,

"Mr. Dickie, what size of a steam whistle do you propose to put on this boat?"

"The usual 6-in. whistle, Mr. B.," I replied.

"Now don't fit anything as big as that, my boy; that boiler will never make steam for a 6-in. whistle."

The same day the president of the Risdon Iron Works made a last effort to shake my confidence by stating that many people had advised him not to permit it to go in the boat, that it would be better to make another boiler as quickly as possible and not add to the present loss by going any further with a boiler condemned by everybody. With Mr. Moore's help, however, I was allowed to go on, and to the astonishment of all the wise ones on the city front the boiler did very well, as I expected, and there was no difficulty in getting the 350 h.p. that the contract required. The revenue cutter *Oliver Wolcott* was also built at this time with a single-cylinder engine. I went so far as to directly urge the Treasury Department to let me change it to a compound, but Mr. Emery, their engineer, would not have it, although in the next cutter built compound engines were fitted.

The Hawaiian government decided at this time to have a steamer to carry the mails between the islands, and Mr. Sam Wilder came up to San Francisco to see about it. I designed him a vessel such as he required and to meet the appropriation for building her, and she was the first steamer built here with compound engines. Before she was completed Mr. Wilder made arrangements with his government whereby he should own and operate the boat, and thus the "Like Like" started what is now a large inter-island navigation company.

From this time on I had the pleasure of building many boats

and engines that have done good service on the Pacific coast. These boats were built of wood, culminating in the steamship *Mexico*, the largest wooden steamship for ocean service that has been built on the Pacific coast. Notable among these vessels was a fleet of steam whalers built between 1879 and 1883. I had the honor of fitting to one of these, the *Balaena*, the first marine triple expansion engine built in the United States.

Now I must take you back to 1874, to the beginning of lively times on the Comstock. Long before the Sutro tunnel reached the group of mines it was expected to drain, and through which the ores were to be transported to the mills on the Carson River, the shafts had been sunk to a depth nearly twice that at which the tunnel was to join them, and great hoisting and pumping works were required to enable the mines to be operated. The mines in operation were divided into two groups, known as the north and south end mines; and they were usually in the control of two groups of capitalists known as the Bank of California crowd, and the Nevada Bank crowd, also known as the Bonanza crowd. The Risdon Iron Works was generally favored by the Bank of California crowd, while Prescott Scott & Co. were generally favored by the Bonanza crowd. I, as engineer of the Risdon Iron Works, was pushed into the wild scramble for the rich jobs that characterized this period, my opponent being Mr. Irving M. Scott, of the Union Iron Works. I might say something here in regard to the late I. M. Scott; for 10 years he and I kept up a brisk rivalry in engineering design to meet the unusual conditions presented by the problems encountered in working the Comstock mines; he was a noble fighter, and one could not help liking him even when it was felt that the victory should have been ours and not his. Mr. Scott was so brilliant in many ways that his ability as an engineer was often lost sight of. Perhaps no one knew him better as an engineer than I did, for we not only worked in competition with each other for 10 years, but we worked together as junior and senior partner for over 20 years, and I am glad to be able to bear testimony to his skill in engineering design and to his masterly powers of organization to bring his design into an accomplished fact. My association with Mr. Scott I consider as one of the pleasantest experiences of my life as an engineer.

The Comstock experience left two distinct results that have borne fruit and exerted a lasting influence on engineering and industries allied thereto on the Pacific coast; one of these results has been productive of much good and the other of much

evil. The engineer who planned and built the huge machines required to meet the new conditions of mining in deep water-bearing strata where chemical conditions heated the water to be handled to near the boiling point, and erected them in places where the heat hardly allowed of life, let alone work, and where a drop of water raised a blister on the skin, had to cultivate self-reliance and had to be full of engineering resources. Many methods were put in operation in this out-of-the-way corner of the world, when there was not time to make records, which have been reinvented since, such as compressing air in two stages and the reheating of air during expansion while doing work. Much original work in hydraulics resulted in attempts to drain the lower levels of the Cholar Norcross and Savage mines through their combination shaft; all this work was designed by me without any precedent to go by, and feeling one's way under the conditions that prevailed in these mines was an education in how to control one's nerves if nothing else. On the 2 400-ft. level running into the old Savage workings we had a stone wall built across the drift, with a pipe and a valve on it to control the flow; when things went wrong and the valve had to be closed the water would rise behind that wall till it stood at 1 700 ft. I often looked at the pressure gage and imagined how it would be if that wall let go. Air chambers had to be charged under a pressure of 2 500 lb. per sq. in. and air compressors designed and built to do it. What we did there gave us courage afterwards to build battleships. This schooling has enabled the Pacific coast engineer to hold his own in all work requiring original design to meet unusual conditions, but at the same time unfitted him for competition in the manufacture of standard work. The big prices paid for work in Bonanza times is still felt, both in the design and in the building of machinery on this coast, and it is to be hoped that it may die with the engineers now nearing the dropping-off side of the stage.

It is much to be regretted that the history of the engineering battles fought on the Comstock cannot now be written with strict justice to all who fought in them. Those, like myself, who were in the thick of the fight could only see and feel their own struggle and narrate what they experienced; but the whole struggle, with the stupendous natural obstacles encountered by the engineers in their attempts to get at the secrets nature guarded so carefully, cannot now, I fear, ever be revealed by any of those who took part in the work. I have often talked with Mr. W. R. Eckhart about it, and I think that he has more

notes of what was done than any one else, but he has not seen his way to use the information he has. Such a history would be a rare possession for the Technical Society of the Pacific Coast, and I have never forgiven myself for not recording all that came within my own observation as it occurred, as memory plays many tricks upon us if we try to drive her back 30 years or so, and I will not risk the danger of her leading me astray.

In 1881 I began to think it necessary for some concern to get ready for steel shipbuilding at San Francisco or vicinity, watching the growth of Pacific Ocean trade and the necessity of keeping a large force of the right kind of men at work to meet the demands that would come suddenly at uncertain intervals for large numbers of men to effect repairs required by accident or otherwise. There was also a growing feeling throughout the country that a modern navy was necessary to enable the United States to take her place among the leading nations of the earth, and I somehow got the notion that a part of that new navy would be built on the Pacific coast. I began trying to interest the trustees of the Risdon Iron Works in my ideas, pointing out to them what I saw coming, and endeavored to show them the necessity of moving their works to the water front, providing the necessary ground and facilities for steel shipbuilding on a moderate scale; but I could not get them to see things as I saw them, and as neither they nor I could change each other's opinion as to the necessity of a shipbuilding plant at San Francisco, I was forced to try the possibility of interesting others in my project.

There were a good many friends of mine with money who had confidence in my ideas relative to shipping matters, so I worked my project up amongst them. A site for a shipyard and dock was selected at Sausalito and preliminary arrangements were made, and it looked to me in the summer of 1882 as if I should be able to start a modest shipbuilding and marine engineering establishment in the quiet shelter of Sausalito Bay; but it was not so decreed. One day a mutual friend of Mr. Irving M. Scott and myself made an appointment with me to call on Mr. Scott that evening, which I did. We had a long conversation on my ideas of the future prospects for shipbuilding and engineering on the Pacific coast; he knew of my efforts to form a shipbuilding and engineering company and told me that the same thoughts had come to him, that the prospect for general engineering was not so bright as it was in Bonanza days

and then suggested that it might be possible to interest Prescott Scott & Co. in my proposition if I could carry my friends into it. We parted with the understanding that he should consult with his partners in regard to the matter and I should see if my friends would join with the Union Iron Works in carrying out my proposition. I found most of my friends willing, though some would not join with Mr. Scott. Finally, however, matters were arranged, a valuation was placed upon the Union Iron Works tools, etc., at the corner of First and Mission streets, and an arrangement was made that a company should be formed to be named the Union Iron Works, to take over the business of Prescott Scott & Co. and the land they owned at the Potrero and establish there an engineering and shipbuilding plant suited to the needs of San Francisco Harbor.

When this work was begun it had not many friends outside of those who had put their money into it; disaster was predicted by all who pretended to know anything about engineering or shipbuilding, and for some years the prospect was not bright to those on the inside; but they had strong hearts and never let their fears reach the outside world. Four or 5 years after the works were established the new navy began to assume definite shape, and we succeeded in getting one of the first 3 cruisers ordered, the *Charleston*, and not long after the *San Francisco*. Twenty vessels of the United States Navy have been built at the Union Iron Works, at a cost of about $32 000 000, and other vessels costing over $8 000 000. An average of about 3 000 men have been employed during the 22 years the works have been in operation, and nearly $30 000 000 have been paid in wages, including all repairs and general engineering work. Nearly 3 years ago these works were absorbed by the United States Shipbuilding Company and the original owners disposed of their interests to the promoters of that unfortunate concern, out of whose wreck Mr. Schwab saved the Union Iron Works. I can follow its history no further, as my connection with these works terminated with the advent of the man Mr. Schwab has placed in command. I shall, however, always be proud of any further success that may come to the works into which I have put the best of my professional life.

There is a condition that the technical man who labors long in one line of work is very apt to fall into, and which my present experience enables me to speak knowingly upon; that is where a man practically loses himself and is lost also to others in his work. For 22 years I had given myself up entirely to the

work as I found it at the Union Iron Works, going from my home every day direct to the works at the Potrero; thus I was never seen in the city in the daytime, and those who knew me as a familiar business figure in the main business streets of San Francisco at first missed me, then gradually forgot me, except as they heard from time to time what was going on at the works. When I had to begin again this year to look for the people who had been my friends so many years ago I found myself in a strange city and among people who hardly remembered the friends I was seeking for, and while many knew my name and something of my work and reputation, yet I have lost my hold on the active men of to-day because I had lost myself and all my friends in the deep grave I had dug for myself in the Potrero. We want to love our work and put all our heart and soul into it, but we must not allow ourselves to be utterly lost in it, for I am finding that after being buried for 22 years in a comfortable shipbuilding and engineering grave, the necessary resurrection is a sort of a Rip Van Winkle return to places where I have long been forgotten. It is one of the evils of our profession that he who is able to accomplish anything worth while in it runs the risk of losing himself entirely in the effort. This is partly the result of the technical education that engineers receive, which absorbs much of the time usually devoted by young men in mercantile pursuits to social intercourse. In early life the engineer gets entirely absorbed in his profession, the very language of which is an unknown tongue except to his professional friends. The technical man gradually becomes self-contained; he is not understood in the society in which he should move, so, late in life, when he needs companionship other than that of the shop, and tries to get into the place in life that he should have always occupied, he finds that no place has been reserved for him and that he must either go back to his old grave that fitted him so well, or industrially set about digging a new grave, probably to die in the effort.

It is this intense struggle that never ends with the engineer if he is to keep abreast with the progress in engineering science, that renders him such a dreary neighbor and chills the social atmosphere all about him; nor do I see any salvation unless he is willing in early life to cultivate more than he ever has done the social habit, and to be able to take delight in the beautiful things around him, to see more in a waterfall than so many horse-power, to be intimate with the things people generally like to see and hear about. We boast very much about the vast

achievements of modern engineering, and rightly, too, but it might not be easy to sum up what the development of engineering has added to the sum total of human happiness. When I look back upon my own engineering experiences I do not find anything that looks now very noble or really worth a man's putting his life into, although a lot of it may have been useful enough at the time. I see only a confused mass of iron beams and steel shafts, hear only the din of wheels and the roar of steam, with here and there a little gleam of something better, and when my memory catches these little bright spots in the picture I find that these were the days that I escaped from engineering and with the wife of my youth got away from the clang and the clamor of these man-made forces, and for a little while crept into the bosom of mother nature, listened to her soothing music, heard the beating of her great heart and rested happy in the thought that I was, after all, one of her children who had tired himself out in fighting her forces. It is a comfort to be able to recall the times and places wherein I came nearest to being happy and to know that these spots are never closed to those tired of the struggle with stubborn circumstances, and it may be that the next hole I creep into will be among the beautiful Santa Cruz mountains. No, it will not be a hole, but "Loma Linda," the hill beautiful, and to such a place, if I get there, it will be my delight to draw many a weary technical that he may learn his child lesson that life is vastly more than an engineering problem.

ASSOCIATION
OF
ENGINEERING SOCIETIES.

Organized 1881.

VOL. XXXVI. MARCH, 1906. No. 3

THE PRESENT STATUS OF THE TURBINE AS APPLIED TO MARINE WORK.

BY HERBERT C. SADLER, MEMBER OF THE DETROIT ENGINEERING SOCIETY.

[Read before the Society, January 26, 1906.]

THROUGHOUT the history of shipbuilding, the attainment of speed, whether high or low, has been one of the fundamental requisites of every design. Depending, as it does, upon so many other conditions, it may not be out of place to repeat, in a general way, the problem that the naval architect must solve.

A floating structure is to be designed which will carry, besides its own weight, a certain weight of cargo, must move at a certain speed for a certain time, *i. e.*, must have a certain weight of machinery and fuel and, finally, must carry this total burden upon a certain draft of water, and do so with safety. It is evident, therefore, that the question of displacement or weight is one of the primary conditions of design.

A discussion upon the resistance of ships is beyond the scope of this paper, but it may be observed that, in general, the less the weight of a vessel the greater the speed obtained with a given horse power. Attention may also be called to the fact that whereas, in high-speed vessels, the weight of machinery and coal may be from 30 per cent. to 50 per cent. of the total displacement, in one of the cargo or intermediate type, this will range from 5 per cent. to 20 per cent. This latter consideration has a very important bearing upon the type of propelling machinery that should be adopted in any given case, and, therefore, immediately affects the subject of this paper.

The requirements that should be fulfilled in any marine propelling instrument are necessarily diverse, depending upon the particular trade or occupation of the vessel. There are, however, certain broad conditions that should be fulfilled by all.

The first and most important is that of *reliability;* this term being taken to mean that the engine will run at its full power for long periods of time with minimum risk of breakdown. The modern marine engines of the ocean liners are prominent examples of what can be done in this respect; but it should be borne in mind that perfection is impossible of attainment, and occasional accidents, necessarily unavoidable. In the merchant marine the failure of the machinery means a loss of time and, hence, money, sometimes a considerable amount, if the vessel is not under control. In war vessels the failure of the machinery at a critical time may turn what would otherwise have been a victory into defeat. Even in pleasure crafts an accident to the machinery may sometimes be accompanied by serious complications. In all, however, the danger of total loss is increased if the vessel be rendered helpless through the breakdown of her machinery.

The second requirement should be one of *economy.* This question is brought home to the naval architect and ship owner more forcibly than to any other designer or power user. From the naval architect's standpoint economy means that a smaller weight of fuel and water is required and hence a saving made in weight and power. To the owner economy not only means a reduction of running expenses, but also decreased first cost, because a smaller vessel may be designed to do the same work as a larger and less economical one.

In war vessels economy means many things, among which may be mentioned increased fighting power or protection, increased speed, or increased radius of action at the same speed.

The third condition should be one of *adaptability* to conditions of propulsion and maneuvering. The almost universal propelling instrument is now the screw, exception being made of of the paddle wheel, the application of which is limited to special types of vessels. The marine engine, therefore, must be capable of running at fairly high speeds of revolution, but the screw propeller again sets an upper limit upon the revolutions beyond which it is undesirable to go. When the phenomenon of cavitation appears, the efficiency of the screw falls off rapidly, and hence very high speeds of revolution are inadmissible. High speed is also accompanied by small diameter of propeller, the

diameter varying inversely as the revolutions. Small propellers are, in general, less efficient than large ones, but there are some compensations in the way of better immersion in cases of light draft and in a seaway, which, to a certain extent, counteract some of the disadvantages.

Another condition of importance is that of maneuvering. A marine engine should be capable of being stopped, started and reversed without difficulty, and by the simplest possible means. In certain cases where the service requires that the vessel should make a number of stops at short intervals, this condition is of primary importance.

In war vessels, also, maneuvering qualities require special attention; but in the case of the average merchant vessel whose trade requires long periods at full speeds and only short ones of backing and handling at each end of a voyage, the above condition does not occupy such a prominent place.

The fourth condition, and one to which attention has already been called, is one of *weight*. The weight per horse power developed should be, in a marine engine, as small as possible consistent with good design. Here again the importance of this depends upon the conditions of service and type of ship; for in cases where the weight of engine is only say 5 per cent. of that of the total vessel, a small percentage saving does not appreciably affect the result; whereas in those cases where this weight is in the neighborhood of 25 per cent. of the total, even a small percentage saving may be accompanied with considerable advantages.

Closely connected with the above is the question of the space occupied and general dimensions of the engine. In a large majority of engines, any saving in space occupied by machinery is a distinct advantage; while in war vessels in particular, the necessity for protection demands an engine whose dimensions in the vertical direction are not excessive.

The final condition and one to which particular attention has been paid in the past few years, is that there should be no unbalanced force tending to produce vibrations when the engine is running.

With this brief résumé of the prominent conditions to be fulfilled by a marine engine, let us proceed to consider in what respects the steam turbine is suitable and wherein it falls short of the requirements.

There are two principal types of turbines, known respectively as the impulse and reaction turbine. These are distinguished by

the pressure existing in the clearance spaces between the guide and rotating blades. If this pressure is greater than that of the steam as it leaves the rotating blades, the turbine is said to be of the reaction type, and if equal the impulse type. There are many other classifications, but at present we need only consider those that have been used to any extent in practice.

As representing the two systems, the De Laval and the Parsons may be said to be typical. The De Laval turbine has one practically insurmountable difficulty, so far as its application to marine work is concerned, and that is its high speed of revolution. In order to bring this within reasonable limits it is necessary to introduce gearing. The high speed at which this gearing must run causes the marine engineer to pause before installing an engine of this type; in fact, high-speed gearing is a method of transmission of energy that should never be used in marine work.

In the Curtis turbine, which is practically a combination of the two systems, *i. e.*, alternate pressure and velocity stages, the number of revolutions has been materially reduced. This turbine, although extensively used on land, has had, up to the present, only a limited application in marine work, so that experience with this particular type is somewhat lacking. There seems to be no reason why, with experience, the Curtis turbine should not be a success when applied to ships.

The success of the turbine in its application to marine work has so far been due entirely to Mr. Parsons, and, as the experience with this type of turbine is the greatest, the remainder of the discussion will be devoted to the application of this particular type.

Taking the conditions previously discussed, in order, the first requirement laid down was that of reliability. In any type of machine, one measure of the risk of breakdown is the number of moving parts. Other things being equal, a large number of joints, moving parts, rubbing surfaces, bearings, etc., is accompanied with a greater chance of stoppage of the whole machine through the failure of one, than where these are reduced in number. In the reciprocating engine the number of parts is unavoidably large, and sometimes an insignificant breakage or overheating may cause a temporary stop. From this point of view the turbine possesses a great advantage in that, so far as the engine itself is concerned, practically the two main bearings are all that require attention. With the present system of forced lubrication this difficulty has been almost eliminated.

The perfect balance and uniform twisting moment, possible with the turbine, also play a somewhat important part in this connection. Up to the present, experience with the turbine in marine work over very long periods has not been possible; but, judging from vessels already running, notably the *Turbinia*, the first vessel to be installed with her present turbines in 1896, and also from the performances of similar land engines, there seems to be no reason for apprehension that the turbine should be inferior to any other type of engine. Certain difficulties have, no doubt, occurred, which with a new type of engine it was almost impossible to foresee, but once these are known their solution should not offer any serious difficulties. Attention has also been called to the gyroscopic effect upon the bearings, when a vessel is in a seaway or turning; but Mr. Parsons has pointed out that in the case of the *Cobra* at maximum speed and in the worst possible sea, these forces would not amount to more than one half of the normal weight upon the bearings. In certain types of turbines, notably those of the impulse principle, the erosion of the blades is liable to cause trouble. In the Parsons type, where the steam velocities are comparatively low, the blades do not give any trouble on this score, at least so far as experience has demonstrated at present.

Closely associated with reliability is ease of repair. To some the multitude of small blades may seem somewhat complex, but in reality this is not so. In the case of one accident, where a number of blades were stripped, the turbine was stopped, the débris removed, and the turbine started again and run for the remainder of the day, apparently without appreciable decrease in power. In all, the accident caused a loss of about three hours.

The first commercial vessel to be fitted with Parsons' turbines was the *King Edward*, built in 1901. Since then this vessel has been run continuously during the summer months and has given entire satisfaction.

No doubt the cylinders of the larger turbines will require considerable attention in design, in order to take care of the expansion. They are apt to distort when heated, especially as the temperature along the cylinder may vary from about 400° fahr. to 100° fahr., thus causing a varying expansion radially. This may lead to increased clearance spaces, but immunity from possible stripping may demand a slight sacrifice of efficiency.

We now come to the second and, perhaps, the most important consideration, viz., economy. So far as direct comparison of turbines of different powers working under different

conditions is concerned, we are met with the difficulty of being unable to determine the indicated horse power of this type of engine. Where it is possible to perform a brake test, such as in land practice, the economy with respect to brake horse power, or horse power delivered, may readily be determined. By making certain assumptions as to the efficiency of the reciprocating engine and applying these to the turbine, we may obtain a quasi-indicated horse power.

It should be noticed, however, that this is not a satisfactory method, and, so far as ships are concerned, a better measure of economy would be the amount of water or coal consumed per mile or hour at different speeds. For definite information as to the amount of water consumed, we must refer, in the first place, to experiments upon land installations.

The results of a series of tests * upon a 400 kw. and a 1 250 kw. machine, built by the Westinghouse-Parsons Company, of Pittsburg, show that the consumption of dry saturated steam per e.h.p. hour at full load was about 14.5 lb.; and at 50 per cent. and 160 per cent. load the consumption was about 17 lb. and 15 lb. respectively. With 190 degrees of superheat, the consumption at full load fell to about 11½ lb. per e.h.p. hour.

On the assumption of 94 per cent. efficiency, these figures would give from 14 lb. to 13 lb. per i.h.p. hour under ordinary working conditions with dry saturated steam. For a good average triple expansion engine under similar conditions, the consumption in all probability would be from 12 lb. to 15 lb., so that from this point of view the steam consumption of the turbine compares favorably with the best reciprocating engine practice.

It is, however, when we come to use superheated steam that the turbine appears in a more favorable light. The economy due to superheated steam is too well known to need any discussion here, but reference is made to the effect of superheating shown in the above figures.

From the results of tests made upon some Westinghouse-Parsons turbines,† the statement has been made that for every 100 degrees of superheat there is a corresponding decrease of 10 per cent. in steam consumption.

No doubt there is a corresponding gain in the reciprocating type of engine, but this fact should be borne in mind, that the

* See paper by F. Hodgkinson, Am. Soc. Mech. Engrs., 1904.

† See paper by I. R. Bibbins, St. Louis Convention of the Am. St. Ry. Asso., October, 1904.

mechanical difficulties resulting from the use of highly superheated steam increase rapidly with the degree of superheat. The principal difficulty lies in the proper lubrication of the internal rubbing surfaces, such as valve faces, pistons and cylinders, where high-temperature steam is used.

In the turbine, however, there is no need of any internal lubrication, and high temperatures do not materially affect the working of this type, provided difficulties due to expansion do not occur.

In a similar manner the gain due to the use of higher vacuum may be represented as varying from 3.5 per cent. to 4 per cent. for each 1 in., depending upon the load. In marine work, reduced power is generally accompanied by decreased revolutions, and as is generally known the efficiency of the turbine falls off considerably under these circumstances. Although data are somewhat lacking upon this point it seems reasonable to suppose that at, say, half power and half the usual number of revolutions the increase in consumption per h.p. hour should not exceed from 40 per cent. to 50 per cent. of the normal amount.

In general, the amount of time at which a vessel is running at reduced speed is exceedingly small, except in special cases, such as war vessels. In these, special means for increasing economy have been devised and will be discussed under the next heading.

From the point of view of economy, therefore, the turbine should show as good results as any other type of engine, especially when its adaptability to the use of superheated steam is taken into consideration.

Before leaving this topic, reference should be made to experiments with exactly similar vessels whose only difference lay in the propelling machinery.

In 1904, the British Admiralty conducted an exhaustive set of trials upon the *Amethyst*, a cruiser of 3 000 tons, fitted with Parsons turbines, and three exactly similar vessels fitted with reciprocating engines. A full report * appeared in *Engineering*, from which the following is taken: Originally up to a speed of 14½ knots, but since certain improvements in connection with the auxiliaries, to a speed of 10 knots, the reciprocating engine has the advantage so far as steam and hence coal consumption are concerned; but above this speed the turbine has the advantage. At 18 knots the reciprocating engine required 24½ per cent., and at 20 knots 40 per cent. more water than the

* See "Engineering," London, November 18, 1904.

turbine. Although some of this difference might be traced to the boilers, the actual amount cannot be great as the heating surface and grate surface were practically the same in all ships.

In the full-speed trials the advantage of the turbine became more apparent; the maximum speed obtained by the reciprocating engine being 22.1 knots, as against 23.63 by the turbine engined vessel, a gain of 1.53 knots, or 6.9 per cent. This is the more remarkable seeing that the boiler installation is the same in all, and the higher speed in the turbine vessel was obtained with slightly less air pressure in the stokehold.

One other case has occurred where direct comparison between reciprocating and turbine engines has been possible. The Midland Railway Company, of England, in 1904 built four vessels, two of which were fitted with four-cylinder triple-expansion engines and two with turbines. This experiment is all the more interesting seeing that one of the turbine vessels is practically the same in all details as the reciprocating type, while in the other full advantage has been taken of the saving in weight due to the turbine, of putting this extra weight into larger propelling machinery.

The vessels were designed for a speed of 20 knots, and the following figures confirm those previously quoted:

From 14 to 20 knots the turbine vessel shows an advantage in steam consumption; between 19 and 20 knots the decrease in consumption is about 8 per cent. in favor of the turbine vessel exactly similar to the reciprocating type, while in the other case, where full advantage was taken of the turbine this figure amounted to 14 per cent.*

From the speed point of view there was also a corresponding gain, the turbine vessels obtaining fully one knot higher speed. An analysis of the results of a number of actual runs under service conditions shows that for the same speed the saving in coal in favor of the turbine amounts to about 9 per cent.; or for the same coal consumption the turbine vessel could be run at a speed of 20.3 knots as against 19.5 knots in the vessel with reciprocating engines.

The Cunard Company is about to carry out a similar set of experiments with two large ocean vessels, the *Caronia* and *Carmania*. These vessels are 678 ft. long, 72 ft. broad and 52 ft. deep, and displace about 30 000 tons. The *Caronia* is already running and developed 22 000 i.h.p. at 19½ knots speed on trial.

* See paper by William Gray, Inst. Naval Architects, London, July, 1905.

The *Carmania* has already made several trips and another direct comparison on a large scale will soon be available.

We now come to the third requirement, viz., adaptability to conditions of propulsion. From the previous discussion, and from the number of vessels already equipped with turbines, the question of the general adaptability of this form of engine is beyond argument. There remain, however, certain conditions which need consideration. Compared with reciprocating engines turbines possess the quality of a relatively high speed of revolution, and it is this consideration which effectually bars certain types from marine work entirely, and places a limit upon the application of others. High speed of revolution is necessarily accompanied with small propellers, which in themselves are not so efficient as the larger ones. When we come to large vessels, the actual size of the propeller plays an important part in the general handling and working of the vessel. Let us consider the principal types of vessels in the merchant service. These may be divided into the cargo boat of slow speed, the intermediate cargo and passenger with moderate speed, and the purely passenger or high-speed type. In the purely cargo boat not only is the power small relatively to the vessel, but also absolutely. For example, a large ocean freighter of, say, 500 ft. in length, and say, 17 000 to 18 000 tons displacement, would not have engines of more than say 3 500 i.h.p., or about the same as that estimated for the *King Edward*. The diameter of the center propeller in this case was 57 in., and the two outside ones slightly less; the revolutions being 505 and 755 respectively. Such small propellers are evidently unsuited for the case in point, and, if the speed of revolution were reduced so that a propeller of larger diameter could be employed, the diameter of the turbines would have to be increased, with the result of little, if any, saving in weight and certainly decreased economy over the ordinary type of engine. We are forced, therefore, to this conclusion, that where the machinery installation or power is small relatively to the vessel, there is no advantage in the use of the turbine, but rather the opposite.

In the intermediate and fast passenger types the conditions just discussed do not hold, as in these cases large or fairly large powers are required, which naturally entail the use of larger propellers, even though the revolutions be kept the same as in the smaller engines.

The one serious drawback that the turbine possesses is its inability to reverse. Although in most cases, in the merchant

marine, an engine is moving ahead for about 99 per cent. of its time, yet the condition of reversibility must be met. In all present arrangements a special reversing turbine is fitted, usually at the end of the low pressure, and runs *in vacuo* when the main turbine is running ahead.

The objection is sometimes heard that turbine vessels cannot be stopped as quickly as those of the ordinary type, and to a certain extent this is true with many vessels. The fact should be borne in mind, however, that the time required to bring a vessel to rest depends largely upon the power exerted, and if sufficient backing power be supplied there is no reason why the turbine vessel should not be as handy as the ordinary type. The objection is, however, a real one, for while in the case of the reciprocating engine the full power is always available for backing, in the case of the turbine, full power in the astern direction would mean a large additional weight and the carriage of a useless engine for the greater part of the time.

Certain experiments upon this question have been performed which tend to show that even with moderate backing power the turbine vessel is fairly handy.

Torpedo boat No. 293 of the French navy, 130 ft. long, displacement 94.6 tons, brought to rest from a speed of 20 knots in $4\frac{1}{2}$ times her own length, or in 585 ft. Channel steamer *Queen*, 323 ft. long, brought to rest from a speed of over 19 knots in $2\frac{1}{2}$ times her own length, in 1 min. 7 sec. Steaming astern, she attained a speed of 13 knots. Channel steamer *Manxman*, 330 ft., brought to rest from full speed (about $22\frac{1}{2}$ knots) in $1\frac{1}{2}$ min.

In war vessels the conditions as to operation at reduced powers and maneuvering are much more severe than those which obtain in the merchant marine. Except in special cases, a warship is seldom called upon to develop her full power after she has completed her official trials. Here the turbine as ordinarily fitted for full power would prove undesirable from reasons of economy.

One method of overcoming this difficulty was that adopted in the destroyer *Velox*, where two small triple-expansion reciprocating engines were connected by detachable couplings to the low-pressure turbines. The steam after passing through these engines was led into the low-pressure turbines and thence to the condenser. This arrangement is undesirable both from an engineering and operative point of view and has since been discarded in favor of the entire turbine installation.

In the *Amethyst* two small cruising turbines are permanently attached to the main low-pressure turbines. At reduced powers the steam first passes through the cruising turbines and then through the main turbines to the condenser, thus giving a large range of expansion. For intermediate powers the steam is admitted first to the intermediate cruising turbine, then to the main high-pressure turbine and so on to the condenser. For full powers the auxiliary cruising turbines are cut out. This arrangement possesses all the flexibility that can be desired, and if reference be made to the steam consumption curves, it will be noticed that these compare favorably with those of the reciprocating engine.

The question of economy at reduced powers is therefore not such a serious matter as one would suppose at first sight; and, in this connection, it is interesting to note that similar arrangements have been made in the vessels of the Russian volunteer fleet: the reciprocating engines in these vessels working as quadruple at ordinary speeds and triple at the higher speeds required on government service.

In connection with the question of weight, there is no doubt that the turbine possesses an advantage over the reciprocating engine. In the case of the Midland railway boats, referred to above, the reciprocating engines, shaft and propellers weighed 280 tons, on the turbines 195 tons, a difference of 85 tons, or 30 per cent. There was also a saving in hull construction weights of about 30 tons, making a total saving of 115 tons.

	Reciprocating.	Turbine.
Boilers	460	390
Engines	210	160
Shafting and propellers	60	25
Total	730	575
Speed	21.9 Knots	22.3 Knots

Even in the foregoing figures full justice is not done to the turbine, when the speed is taken into consideration.

For the same weight of machinery in the case of the *King Edward* the speed of the turbine boat was 20.5 knots, as against 19.7 probable speed, if reciprocating engines had been fitted, or a gain in horse power of about 20 per cent.

In the case of the cruiser *Amethyst*, the weight of machinery was practically the same as that of the reciprocating engined

ships, viz., 530 tons. The speed of the *Amethyst* was, however, 23.63 knots against 22.1 for the other vessels.

	Reciprocating.	Turbine.
Engines and boilers	537	535
I.H.P.	9 900	(14 000)?
Speed	22.1	23.63

For the same speed and displacement there would be a saving of about 155 tons, or nearly 30 per cent., on the weight of machinery alone. This would also be accompanied by less coal and water, or if these were increased so as to keep the total weights the same, there would be a corresponding increase in radius of action.

With regard to floor space occupied, there is nothing to choose between the reciprocating engine and the turbine. In space taken up in the vertical direction, the turbine has a distinct advantage, although in the merchant marine this may not always be an unmixed blessing on account of the tonnage laws.

The situation may, therefore, be summarized briefly as follows: So far as reliability is concerned, there seems to be no reason why the turbine should be inferior to the reciprocating engine; while from the point of view of economy and speed, the turbine has shown itself in many ways superior. At very low speeds, however, the reciprocating engine is superior in economy of steam, but against this the turbine requires less oil and a slightly less engine-room staff. The turbine in its present state is not suitable for all classes of ships. Where the speed is high or fairly high, that is, in passenger and intermediate types, war vessels and yachts, it may be used to advantage; but in slow cargo vessels where the power is small relatively to the size of ships, and for those vessels which require to be started and stopped at frequent intervals, the turbine is not suitable. From the weight point of view the turbine is certainly superior to the reciprocating engine of the same power, especially in the case of ordinary high-speed vessels. It possesses also the advantage of being perfectly balanced, and hence the vibrations of the vessel may be considerably reduced. From figures available, the cost is slightly in excess in the case of the turbine, but as the speed of the vessel is usually greater, this is more apparent than real. So far as space occupied is concerned, there is little to choose between the two, the turbine having the advantage so far as height is concerned.

In conclusion, it may be interesting to note the number of

vessels built and building, in which the turbine in some form, although mostly of the Parsons type, is employed. In the merchant marine there are some forty-three, ranging in size from small yachts to the new Cunard vessels which will have in the neighborhood of 65 000 i.h.p. Five naval vessels have been built and twenty-one are building, making a total of some seventy-eight vessels in all.

ANNUAL ADDRESS.

By Ernest W. King, President of the Montana Society of Engineers.

[Read before the Society at Lewistown, Mont., January 13, 1906.]

To the Members of the Montana Society of Engineers, Lewistown, Mont.:

Gentlemen,— Another year has rolled around since our last annual gathering, and it is certainly a great pleasure for me to see the contented and prosperous look on so many of the old-time faces that I see before me, and to know that Father Time has dealt so leniently with you all. But when one stops to think of the quiet and simple life led by an engineer, his abstinence from the use of all intoxicating beverages or stimulants, except at annual meetings and in emergency cases, and of the close touch that the very character of his work brings him into with nature, it is not to be wondered at that so many of the old faces that I see before me have such a youthful appearance.

It is also very gratifying to see so many of the younger members of the profession with us here to-day, and it is to be hoped that they will profit by the example of strict honesty, sobriety and close attention to business that has been characteristic of the older members of this society, and that their works in the future upbuilding of the great state of Montana will be recorded with pride in the records of this society and the future history of our beloved state as have been the records of the work of the older members of this society; for it is a matter of history that about all of the great engineering ventures in the state, such as the locating of the principal railways, the building of the large smelters and refineries and the great mining plants, the dams and electric-power plants and the great irrigation schemes that are bringing Montana so fast to the front, have been designed and brought up to their present high state of efficiency by members of this society.

The society has been visited but once by the grim reaper, Death, during the past year, and we have been called on to mourn the loss of our esteemed brother, E. R. McNeill, one of the old-time members of the society and one of the pioneers in railroad work in this state. At a regular meeting of the society,

held December 9, the following resolutions were unanimously adopted:

Whereas, God in his providence has removed from our midst Brother E. R. McNeill, a member of this society, now, therefore, be it

Resolved, That in the death of Brother McNeill this society has suffered an irreparable loss. His sterling qualities of head and heart were well known to his intimate friends, and his conscientious discharge of every duty intrusted to him is testified to by his employers, as well as by those associated with him on engineering work.

During a long period of active service on railroad engineering in Montana, Mr. McNeill was known as one of the most thorough and painstaking engineers, on some of the most difficult work ever executed in Montana.

" *Resolved*, That this society shall express, by these resolutions, its sincere sorrow on the death of Mr. McNeill, and these resolutions shall be spread upon the minutes of the society and a copy forwarded to his bereaved family.

Finley McRae,
Wm. F. Word,
Frank L. Sizer,
Committee.

Owing to the fact that a number of railroads are heading toward Montana, there is a great deal of secrecy maintained by all of the railway companies as to the work they are doing or contemplate doing, and it is very hard to get any actual facts as to future construction work, but it is safe to presume that there will be something doing in Montana for the next year or two in the way of railroad building, as well as in a great many other lines.

One of the engineering features in Montana to-day that bids fair to outrival all others and do more for the general upbuilding of the state, is that of irrigation, and we will take that for our starting point.

Irrigation.

Nature has provided Montana with several million acres of rich soil that is suitable for raising all kinds of grains and cereals, and she has also provided abundant water to irrigate every foot of this land, but she has shown the same good judgment in this that she has in other things. The precious and other minerals have been placed deep in the bowels of Mother Earth and in very inaccessible places, so that it requires a great amount of money

and continuous labor of a vast army of men to extract them and convert them into mediums of exchange and useful articles for the benefit of man.

She has placed the land and water at the disposal of man, but she has so located the streams in the mountains that it takes a large amount of money and the labors of a vast army of men to bring the waters to an available point so that they may be used to the best advantage on the land. All of this work was done at first by enterprising individuals, but it was soon found that no one individual or company of individuals had sufficient capital to handle the larger irrigation enterprises, and that it could not be done without the coöperation of our national government. This coöperation was hard to get, as nearly all of the eastern senators and representatives were not in favor of expending large sums of money in reclaiming what they designated as parts of the great American desert, or lands that were only fit for the home of the rattlesnake and the howling coyote. But the indomitable perseverance of our western senators and representatives won out in the end and appropriations have been made for preliminary surveys and for the construction of some of the larger enterprises, so that it is almost an assured fact that within the next ten years there will be over one million acres more land under ditch than there is at the present time.

Up to the present time the government has under consideration seven different irrigation projects in Montana, and two of them have been accepted by the Secretary of the Interior and are now in course of construction. The two now in course of construction are the Lower Yellowstone and the Huntley canals.

The water for the Huntley Canal is taken direct from the Yellowstone River near Huntley, and at the head gates will have a capacity of 400 ft. per sec. For the first 2 miles the canal follows along the Huntley bluffs, requiring three tunnels with a total length of 1 500 ft., and at a point 14 miles from the head gates there is a drop of 33 ft. where power can be developed to irrigate 4 000 acres above the line of the canal. This, however, will require an additional canal about 6 miles long. The total length of the main canal will be about 30 miles, and it will irrigate over 30 000 acres.

Lake Basin.

Preliminary surveys have been under way for the past three months for the lake basin. This basin is about 25 miles north of Billings and comprises over 200 000 acres of good land.

Clark's Fork.

The field work has been completed for this watershed and it is expected to irrigate about 75 000 acres. The lands to be reclaimed lie principally on the left or west side of the stream and extend from Yellowstone River to the Wyoming line.

Madison River.

This scheme contemplates taking the waters from the head of the Madison and Jefferson rivers and irrigating all of that section between Three Forks and the Prickly Pear Valley, and would cover over a quarter of a million of acres. The field work on this project is about completed, and by March 1 enough data will be available to determine the feasibility of the scheme.

Milk River.

The field work has all been completed on the Milk River project and has been approved by the Secretary of the Interior. This scheme contemplates the construction of a large dam at St. Marys Lake, using the lake as an immense storage reservoir, and conducting the waters from the lake by canals to the head waters of the Milk River, and in turn the waters will be taken from the Milk River to large natural reservoirs so that all of the flood water can be stored in the spring and made available during the irrigation season. The Milk River will be used as a natural canal for carrying the water, and numerous canals will be taken out of the river to irrigate the various tracts of land adjacent thereto. It is estimated that this project will reclaim over a quarter of million acres of land.

Sun River.

Surveys have been completed during the past season on the upper Sun River, about 40 miles west of Great Falls, and several different canal lines are being considered. It is intended to take the water from the river near the mouth of the canyon out in canals on each side of the river, the one on the south side to extend about 50 miles southeast across the Fort Shaw Indian Reservation to the Sun River Bench, just west of Great Falls, and the canal on the north side to extend past Choteau, Freezeout Basin, and down to the high benches near Benton Lake, about 12 miles northeast of Great Falls. A number of good reservoir sites have been located along each of the canals and they will provide ample storage capacity for all of the flood water in the spring of the year.

The construction of the above government works will involve the expenditure of a great many millions of dollars in the next few years, the greater part of which will be paid out for labor to the wage earners of the state and will also provide means for thousands of families to make a good living in the tilling of the soil reclaimed.

The Rosebud Land and Irrigation Company of Forsyth has bought a large tract of land from the Northern Pacific Railway Company and has taken a ditch 25 miles long out of the Yellowstone River, opposite Forsyth. The water is diverted by means of a small dam and concrete head gates, and the ditch will reclaim about 13 000 acres.

The Rancher Ditch Company, a coöperative company of actual settlers, about 25 miles west of Forsyth, has taken out a ditch about 15 miles long and has reclaimed about 6 000 acres in what is known as the Rease Bottom. The head gates are located near Hyshal.

Twenty-five miles east of Forsyth is also another large tract of land, known as the Hathaway Bottoms, that will be reclaimed during the coming summer.

Billings Land and Irrigation Company.

The Billings Land and Irrigation Campany, a company composed largely of local capitalists, undertook, in 1903, to furnish water to irrigate all of the lands acquired by the state under the Carey Land Act, and also a large amount owned by the Northern Pacific Railway and private owners. The work was started in January, 1904, and has been pushed steadily ever since. State Engineer John W. Wade says: "The Billings Land and Irrigation Company, which has the contract with the state to furnish these lands with an adequate and permanent supply of water, is doing this work of construction in such a way as to insure an ample capacity in the canal to do the work of delivery of all the water that will be needed in the reclamation and cultivation of these lands, and all other lands on the Billings Bench comprising sections alternating with those of Carey selections. I have noted not only the capacity of the canal as it is being built, but have also considered the work as to its permanency. The contracting company deserves special credit for the unhesitating policy with which, manifestly, it proposes to proceed, and ultimately to turn over to the settlers an irrigating plant which, for permanency and stability, is not excelled anywhere in the state. There is a small percentage of fluming

in the length of the canal and this is to be very substantial. The tunnel is in a solid character of rock, and (barring the approaches, which will be so 'thorough-cut' as to make caving very nearly impossible) this will not need the slightest timbering or other interior supports."

The tunnel of which Mr. Wade speaks is one of the features of the work, being a bore through solid rock 1 847 ft. long. It is 7 by 8 ft. in dimension and has a grade of 10 ft. to the mile. The capacity is 500 cu. ft. of water per sec. From the tunnel the water flows into a flume 900 ft. long and averaging 60 ft. in height. It carries a flume 6 by 10 ft. inside. The posts are timbers 10 in. square, extending full length from the flume bed to the ground, where they rest on concrete foundations 3 ft. square and 3½ ft. deep. The posts are of Puget Sound fir.

The main canal is to be 70 miles long, 40 of which have been completed. The water is taken from the Yellowstone just above Clark's Fork, where it is diverted into a ditch 21 ft. wide at the bottom, 44 ft. at the top and carrying 5 ft. depth of water. The irrigated lands lie just north of the Crow Reservation on the Huntley flats, just across the river from the reclamation project of the government service. The big tunnel is just across the Yellowstone from Billings, and the first lateral begins irrigation of the lands about 1½ miles east of the city.

Besides the state lands taken under the Carey Act, the school and university lands and those privately owned, 12 680 acres of land were purchased from the railroad company, the terms of sale making it binding upon the irrigation company to furnish a perpetual and adequate supply of water to settlers purchasing lands designated railroad lands within the tract. Altogether 35 000 acres are in the tract, and tributary to the canal across the river lie 3 000 acres for which the ditch has capacity and which it could cover by the construction of a pipe line.

There are numerous other smaller enterprises being handled by private capital, all of which enterprises will go to swell the grand total of acreage that will be soon changed from a comparative waste or desert to happy and prosperous homes, for thousands and thousands of what our great railroad magnate, James J. Hill, calls the backbone of the country, the Honest Farmers.

Water Power.

The rapid development in the field of electrical operations during the past few years has probably done as much to bring

Montana to the front as any one industry within its borders. It has made it possible to operate street car lines, factories, smelters, mining plants, pump water for irrigation and even to operate telegraph lines, etc., from sources of power that a few years ago had no commercial value whatever.

There are a number of new improvements in the use of electricity that not only the general public, but a great many engineers are not aware of.

The current for operating the telegraph instruments on the lines of the Northern Pacific Railway, the Great Northern Railway and the Western Union Telegraph Company in Butte and Helena is furnished from the power plant at Canyon Ferry.

Raising water from deep mines is now accomplished by electrical hoists that work entirely automatically, a noted example of this being in a coal mine owned by the Lackawanna Railroad Company. The water is hoisted by a skip that fills and dumps and reverses its motion at the top and bottom entirely automatically, and all that is necessary is to turn on the current and oil the machinery at stated intervals.

Great improvements are also being made in hoisting ore by the use of an electric hoist. Owing to the great variation in power used in hoisting plants, it has been impossible to contract for electrical power at anything within reason, as, for instance, take one of the large plants in Butte, using a 2 000 horse-power hoist; the actual load hoisted would not require over 300 h. p. running continuously, yet it would be necessary to pay for the full 2 000 h. p. if it were bought from any of the power companies. This is being overcome now by using a motor generator set, of which there are a number now in use. The General Electric Company is now installing several of these hoists in Mexico at El Cro for the Mexican Light and Power Company, and they will probably also install two plants in Butte in the near future, one for the M. O. P. Company and one for the Butte Copper and Zinc Company at the Emma Mine.

The method of operating is to have a slow-speed, continuous-current motor, either geared or directly connected to the hoisting drum. This receives its current from a continuous-current generator driven by a motor. The motor generator set runs at a high speed and carries a fly wheel. This fly wheel is of sufficient capacity to operate the hoist for one continuous trip without any power being supplied from the system. The object of the fly wheel is to store up power during nine tenths of the time that the hoist is idle and to give it out during the few seconds

that the hoist requires it. The result is that the power drawn from the supply system is practically constant and the wide fluctuations in current are confined to the connections between the hoisting motor and the generator. The power drawn from the system is, therefore, only a fraction of that required to start the hoist.

The system of control is by regulating the field of the generator, and, therefore, the voltage supplied to the motor on the hoist. This means that only 1 or 2 per cent of the power current passes through the controller and makes it a much more easily handled piece of machinery, and the speed of the hoist can be controlled from full speed to just barely moving. The cost of the motor generator set, fly wheel and motor on the hoist is only about 50 per cent. greater than the induction motor connected direct to the hoist, so that the extra cost of installing is as nothing compared to the cost of power that would be saved by the new method.

The use of electricity for operating rock drills is becoming more and more in favor with mining men, and I believe that within a few years they will entirely do away with the old compressed-air drill that is used so extensively to-day.

There are several types of electric drill on the market now that will do as much work as any of the air drills and with less than one sixth of the power; but so far the breakage and repairs on the electric drill are so much heavier than on the air drill that it has not come into general use; but the Yankee engineer will soon overcome these difficulties.

There are several large water powers now in course of development to be used exclusively for generating electricity and transmitting it a long distance.

Missouri River.

The Missouri River has already been harnessed at Great Falls and at Canyon Ferry and both plants are taxed to their utmost. A third company has been incorporated, known as the Helena Power Transmission Company, composed practically of the stockholders of the Missouri River Power Company, the present owners of the Canyon Ferry dam. The new company is now building a new dam across the Missouri at a point about 18 miles below the Canyon Ferry dam and about 18½ miles from Helena, just below the mouth of Prickly Pear. The dam will be constructed entirely of steel and concrete, will be 500 ft. wide on the overflow, will have a total width of 900 ft. and 65 ft. height and will back up the water about 17 miles.

There will be over 2 000 tons of steel and 25 000 barrels of cement used in construction and there are now about 300 men at work on the enterprise.

The power station will be first equipped with four main units of 4 000 h. p. each, but the capacity of the plant, when completed, will be 25 000 h. p.

The machinery is all being furnished by the Westinghouse Electric and Manufacturing Company of Pittsburg, Pa., and the steel for the dam is being furnished by the Wisconsin Bridge and Iron Company of Milwaukee, Wis. The total cost of the plant, including the sub-stations in Butte and Anaconda, will be about eleven hundred thousand dollars and the power will be used principally in the mines and smelters of the two last named cities. This work was designed and is being constructed by M. H. Gerry, Jr., a member of this society.

Madison River.

In the narrow canyon of the Madison River, about 8 miles from Norris, is about completed the largest water-power plant in the state. The dam, which is all completed, is 45 ft. high, 232 ft. long and 98 ft. wide at the base, and backs water up a distance of 4 miles, forming one of the most beautiful bodies of water in the state.

The water is carried from the dam to a point above the power house, a distance of 8 000 ft., through two 10-ft. wood-stave pipes, discharging into a forebay 30 ft. by 60 ft. by 30 ft. deep, excavated from the solid rock. From there it is carried to the power house below by four steel pipes, each 9 ft. in diameter, and delivered to the wheels under a head of 127 ft. The power house is 200 ft. long by 60 ft. wide, and the walls are 30 ft. high. It is built entirely of steel and concrete and will be equipped with traveling crane and all modern appliances for repairs, etc. The plant when completed will have a capacity of 50 000 h. p. The current at the plant will be generated at 10 000 volts and will be stepped up to 40 000 volts and delivered to the distributing station in Butte, at the foot of Montana Street, where it will be stepped down to 2 200 volts for commercial use. The company expects to deliver this power to all points within a radius of 100 miles from its power plant. It has already secured the electric-light and street-car plants in Bozeman and expects to have them operating with its current next month. It also expects to extend its lines to Livingston, Virginia City, Dillon, Whitehall and several other smaller towns,

besides Butte and Anaconda. It also contemplates building an electric railway though Gallatin Valley and up the Flathead Valley, north of Bozeman. This plant was designed by, and is being constructed by, Harry Turner, Max Hebgen and Mr. Craven, all members of this society.

Bonner.

Hon. W. A. Clark has recently acquired the electric plant in Missoula, and he is building a dam at the confluence of the Big Blackfoot and Hell Gate rivers, a few miles from Missoula, and power will be carried to Missoula from this dam for operating electric lights and street-railway plants.

Livingston.

A water power is being developed on the Yellowstone, by taking out a ditch about 9 miles long. This plant is expected to develop about 9 000 horse power, and it will be used principally in Livingston.

Beet Sugar.

The wonderful success made in Utah and Colorado of manufacturing beet sugar has started investigations in all parts of the country as to the adaptability of different soils for raising sugar beets, and by actual experiment it has been found that the soil in several parts of Montana is peculiarly adapted to this work, and especially where the soil can be irrigated by a never-failing supply of water.

The location of a beet-sugar plant was taken up by the enterprising citizens of Billings, and in a very short time they succeeded in interesting with them the owners of three plants in Colorado, and in November, the contract for the construction was let to the Kildy Manufacturing Company, of Cleveland. This is one of the three companies in the United States equipped to build such factories complete. The plant will have all improvements of value in the way of machinery and equipment and will cost over a million dollars. The main building will have a ground area of 380 ft. by 85 ft., and will be four stories high. The "Steffens process" building will be 100 ft. by 80 ft. and the power house will be 150 ft. by 50 ft. The engines will develop approximately 2 500 h. p. All construction will be of steel, concrete and brick, making the buildings thoroughly fireproof.

Process of Manufacture.

The beets are brought into the factory from the wagons and cars by flumes in which they are floated to the elevators. They are then carried to the top of the building where an automatic scale weighs them and registers the weight. Then they are dumped into the slicers, huge tanks beneath which corrugated knives revolve horizontally. The sliced beets, now called "cossettes" are carried on a belt conveyor to the diffusion cells. Water is forced through the cossettes until all saccharine matter is absorbed, after which the remaining pulp is dumped into silos for use as feed for stock.

The sweetened water passes through various processes to remove the various salts gathered from the soil by the beets. These are dissolved and absorbed along with the saccharine matter in the diffusion process. To remove these the juice is mixed in the first carbonation process with milk of lime, the chemical action precipitating certain of the salts. The liquid is then put through filter presses, from which it passes to a second carbonation where the process is repeated. The juice is then subjected to sulphur fumes and a third filtration. It is then introduced to a quintuple effect evaporator, where the super-moisture is driven off and it is reduced to the proper density for boiling. It is boiled to a sugar grain in vacuum pans, and is separated from the molasses by a centrifugal machine, from which the sugar passes through a drier to the bag. The lime used in the process is burned by the company itself, in order to insure the absolute purity, which is essential; otherwise the quality of the sugar might suffer. About 8 000 tons are used during a season. The experts of the company are now in search of a satisfactory deposit of lime rock on which the Billings factory may depend.

The operation of the factory is to begin October 1, and will continue four months each year. The plant will have a capacity of 1 200 tons of beets daily, producing from 3 000 to 3 500 bags of "A1 Standard" granulated sugar. It will have about 300 common employees, with a payroll of $900 to $1 000 daily. The experts employed in directing the work will bring the daily expense up to $2 500.

The business men and farmers of the Gallatin Valley have also taken the matter up and arrangements have been about completed for the erection of a plant at Bozeman, and with a fair prospect of having one located at Manhattan.

The settlers of the Milk River Valley have not been asleep

during this time, and they claim that they are in a fair way to get a plant located near Chinook or Harlem.

Railroad Building.

From present indications it would appear that all eyes, especially railroad eyes, are turned toward Montana this year.

The Burlington, or rather James J. Hill disguised as the Burlington, is pushing its survey as rapidly as possible on its line from Billings to Armington, to connect the present terminus of the Burlington with the Great Northern system. The contract has already been let to Mr. La Folette, a relative of Mr. Hill, and he has already begun to form his outfits and get ready to start in the immediate future. So far as can be learned, this line will cross the Yellowstone west of Billings.

The Chicago, Milwaukee & St. Paul Railway has also a number of engineering parties in the field, locating a line through Montana with the intention of going to the coast.

The Montana Railway has a party of engineers in the field locating a line from Forsyth up the Musselshell and past White Sulphur Springs to Helena.

The Soo people are not sleeping either. They have a party of engineers in the field and have taken soundings on the Yellowstone at Sidney for a bridge, and practically have their line located from there to Jordan in Dawson County.

The Northwestern is also in the field with engineers and is gathering data with an eye to building through the state, so that there is a possibility of five different roads being under construction within the next one or two years.

Mining.

While agriculture will in no distant day be the leading industry in the state, up to the present time and for some years yet to come the mining industry will lead all other industries in Montana, and keep her at the head of the list of mining states in the Union. In my opinion, the state has hardly been scratched over yet, and new districts will be opened up that will surprise even the old-timers in their richness.

In the early sixties, the only tools necessary to start out mining were a pick and shovel, gold pan, six-shooter, supply of grub and lots of nerve, and the only metal looked for was gold in its free state. As the gold was found in larger quantities and at considerable depth to the bed rock, the cradle, the ground sluice and the hydraulic giant were brought into play, but no attempt

was made to save anything except the gold, and the presence of silver and copper, as was the case in the early days of Butte, was considered as a detriment to the workings. But gradually new machinery was brought into play for mining and hoisting the ores from quartz veins and for milling and smelting them to recover their values, and there has been a gradual improvement in the methods used in mining, hoisting, milling and smelting from then to the present time. The modern concentrator has made it possible to handle ores of a very low value by taking out nearly all of the silica and other impurities before it is turned over to the smelter.

The modern dredge has made it possible to recover the gold from the bottom of old river channels and places where it was impossible to think of working without it, and a number of dredges are working in Montana at a profit on old placer workings that yield from five to eight cents per cubic yard.

The cyanide process for treating gold ores has been perfected within the past thirteen years, and has made it possible to treat ores at a profit carrying as low as $1.50 per ton, where conditions are favorable for mining the same, and the use of electricity generated by water power has made very rapid advances in all classes of mining.

There have been no radical changes in any of the methods of recovering values from ores during the past year. Probably the Hancock jig has been one of the simplest improvements in concentrating that has been brought out. In the Butte Reduction Works, three of the Hancock jigs are doing the work of fifty old-style plunger jigs, and with about one twentieth of the power, and at the Boston and Montana Concentrator in Great Falls one of the Hancock jigs does the work of about thirty of the ordinary jigs.

While there have been no large plants erected during the past year for mining or smelting, there are a number of smaller improvements going on all the time.

A new working shaft is being sunk on the Leonard Mine, and is now completed to the 700 ft. level. It is a four-compartment shaft, each compartment being 4 ft. by 5 ft. A new engine has been ordered and the foundation is ready to receive it. The engine will be 32 in. by 72 in. cylinder, capacity 34 000 lb., depth 3 500 ft., using a 1½-in. round rope.

At the Mountain View Mine a new hoisting engine is being installed, made by the Webster Camp and Lane Company, double cylinders 28 in. by 72 in., capacity 21 000 lb., depth

3 500 ft., using flat rope ½ in. by 7 in. A complete new engine house and boiler plant are being put in also.

At the North Butte Mining Company, a new double-cylinder hoist is being installed, double cylinder 32 in. by 72 in., capacity 34 000 lb., depth 3 500 ft., using a 1½ in. round rope.

At the Washoe Smelter at Anaconda, arrangements are being made to use electric power exclusively as soon as the new Missouri River Power Plant is completed. Two big blast furnaces have been installed and started during the past year. These furnaces are the largest of their kind in this country, being 612 in. long by 54 in. wide, and all of the reverberatory furnaces have been changed to the long furnaces which are 112 ft. 6 in., by 19 ft. each in the hearth.

At the Butte Reduction Works the plant is receiving a general overhauling. A new steel converter building, 108 ft. by 211 ft., is being erected to be equipped with the most modern converters made, and everything will be operated by electricity. The new cement and steel stack just completed is quite a novelty and deserves more than a passing mention. The following description was furnished by James Doull, superintendent of construction:

The Large Weber Steel Concrete Chimney, at the Butte Reduction Works.

For the foundation of this chimney the ground was excavated to a depth of 7 ft. below the surface, on a level with the water of the Blacktail Deer Creek, and close to the south bank of the creek, the formation of the ground being a natural washed sand deposit. Into this excavation a box was made of cast-iron plates, being 100 ft. square and 3 ft. deep, and into this box was poured molten slag, making a solid block of this size. The foundation was built up by a series of these slag blocks, 3 ft. high, each block being stepped in from the outer edges of the one below 3⅓ ft., thus forming a stepped pyramidal form. There are six of these blocks, making a slag foundation 18 ft. in depth and 66⅔ ft. square on its top surface. While the molten slag was being poured into the boxes, layers of steel wire rope, chain and T-rail were sewed horizontally through each block, and standing vertically through these blocks of slag and projecting out of the top of the slag foundation, and into the stack foundation base, was all manner of scrap iron and steel which usually accumulates around a smelter, there being 70 tons of this material used. The total weight of the slag foundation is

12 800 tons. On top of this foundation was built the foundation base of the chimney, this foundation consisting of a solid block of concrete, made of Portland cement, sand and crushed slag, being $42\frac{1}{2}$ ft. square and 5 ft. high at its sides and $8\frac{1}{4}$ ft. high in the center. The top of this block was shaped like the frustum of a pyramid. Horizontally through this block of concrete were laid four layers of $1\frac{1}{4}$ in. by $1\frac{1}{4}$ in. T iron, two layers being laid parallel with the sides of the block, and two layers diagonal. Into this network were placed vertically, and in a circle corresponding to the size of the chimney, 500 bars of $1\frac{1}{4}$ by $1\frac{1}{4}$ T steel, these bars being all bent outwardly at their lower ends, forming a network similar to the roots of a tree. The upper ends of these bars projected up out of the concrete base to receive the wall of the chimney. On top of this block of concrete was started the chimney, the walls of the chimney being formed by a unique system of sectional molds. These molds, when coupled together, formed complete rings. Two sets of the molds were used on the inside and two sets on the outside, each mold being $3\frac{1}{2}$ ft. high. When one mold was filled, the lower one was detached and laced on top of the newly filled one, this system being followed to the top of the chimney. When a set of molds or rings was in position, the concrete was elevated in buckets and dumped between the molds and thoroughly stamped all around the vertical and horizontal steel bars, thus bedding all the steel into the wall of the chimney. There were 500 of these vertical bars in the chimney at the base extending up for 25 ft.; each succeeding 10 ft. of height the number used was reduced by 20 bars up to a height of 275 ft., and 30 vertical bars were then used to the top. The vertical bars were lapped 2 ft. at the joints and all joints were made at irregular intervals. From the base to the top, rings of 1 in. by 1 in. T iron were laid horizontally, exterior to the horizontal bars and wired to them. For the first 21 ft. these rings were laid every foot in height, and from this point to the top, every 3 ft. in height. For the first 21 ft. of the height of the chimney, the walls are 18 in. in thickness, and in these walls are two inlets to the chimney, one on each side, each opening 8 ft. by 17 ft. On top of the 18-in. wall starts the double shell of the chimney, the outer shell being 9 in. thick, the inner shell 5 in. thick, the shells being separated by a 4-in. air space, this air space at the bottom being connected with the atmosphere through the outer shell by port holes. The inside shell extends up to a height of $101\frac{1}{2}$ ft. above the base, and the outer shell is offset over the inner

shell as will be noted on the exterior of the chimney. The air space is left entirely open on the inner side of the chimney and the inner shell perfectly free from the outer shell at the top. The outer shell is then carried 7 in. thick to the top of the chimney.

There were used in the construction of the chimney, 69 tons of T steel, 1 500 barrels of Utah Portland cement, and 1 400 tons of sand. The weight of the chimney is as follows:

Slag foundation	12 800 tons
Concrete base	1 000 tons
Chimney	1 475 tons

The dimensions of the chimney are:

Surface area of foundation	10 000 sq. ft.
Area of concrete base	1 806 sq. ft.
Outside diameter of chimney at base	21 ft.
Outside diameter of upper shell	19 ft. 2 in.
Inside diameter at base	18 ft.
Inside diameter at top	18 ft.
Height of slag above surface	11 ft.
Height of concrete base	8¼ ft.
Height of chimney	333⅓ ft.
Total height of chimney above surface	352 ft. 7 in.
Height of chimney above grade at intersection of Montana Street and N. P. tracks	351 ft. 10½ in.

Elevation of top of chimney above sea level, 5 791.3 ft.

The top of the chimney is on a level with the following streets of Butte: 60 ft. north of Copper Street, on Main Street; 60 ft. north of Woolman Street on Excelsior Avenue; 11 ft. higher than the elevation at the School of Mines; level with the northwest corner of Montana Street and Quartz Street.

The chimney is the largest and highest concrete chimney in the world, and one of the largest chimneys of its height in the United States. The dimensions of some of the large chimneys in the United States are as follows: Washoe Copper Company, at Anaconda, largest in the world, of brick, 30 ft. inside diameter and 300 ft. high; Metropolitan Street Railway Company, New York City, of brick, 22 ft. inside diameter and 353 ft. high; Clarks Thread Works, Keanry, N. J., of brick, 11 ft. inside diameter, 335 ft. high; Omaha and Grant Smelter, Denver, Colo., of brick, 16 ft. inside diameter, 350 ft. high; Oxford Copper Company, Constable Hook, N. J., radial brick, 20 ft. inside diameter at base, 13 ft. at the top, 360 ft. high; Tacoma Smelting Works, Tacoma, Wash., concrete, 18 ft. inside diameter, 300 ft. high.

The slag foundation was designed by James Doull, of the

Butte Reduction Works, and put into place under his supervision, and was originally intended for a brick stack of the same internal dimensions as the present concrete stack. The concrete base and chimney are the design of the Weber Steel Concrete Chimney Construction Company, of Chicago, and the entire work of erection of same has been under the direct supervision of Mr. Martin Steiler, and certainly stands as a monument to his ability as a chimney builder. The chimney has been tested by instruments as it progressed, and stands perfectly plumb.

At the Kendall Mine, here in Fergus County, there have been installed a 150 h. p. double drum electric hoist and a new seven-drill Fergusol compressor. The new three-compartment shaft is now down 600 ft.

At the Barnes King Mines, electric power has been adopted for operating the mill and compressors, and lighting the mines. The company has recently put in a Sullivan electric diamond drill that is working very satisfactorily.

At the Gold Reef Mines at Gilt Edge, there is now in operation the only roasting plant in the state for roasting ores for treatment by cyanide process, and they have demonstrated that sulphide ores can be successfully cyanided.

General Outlook.

The general outlook for the future prosperity and rapid growth of Montana has never been brighter. The vast area of agricultural lands that will be reclaimed, the building of beet sugar factories, the increased production of our metal mines, the building of a great many additional miles of railroad, and the opening up of numerous new coal mines, as is sure to follow the building of new railroads through sections where coal is known to exist, will give employment to double the men that are now employed in the state.

My address would not be complete if I did not make mention of one more industry in which we all take pride, and that is the Montana School of Mines. Located as it is, in the heart of the greatest mining camp on earth, with every chance for the students to keep in the closest possible touch with all the latest methods of mining and metallurgy, and with an able corps of professors and a well equipped school, the class of young engineers it is turning out each year is second to no school of mines in the country. I speak from experience in this matter as I have sampled its product by employing several of its graduates, and I have found them to be 100 fine.

MADISON RIVER POWER COMPANY'S PLANT.

By G. W. Craven, Member of the Montana Society of Engineers.

[Read before the Society, January 13, 1906.]

In 1896, surveys of the Madison River valley were begun near Norris, Mont., and continued for some 60 miles south, with the intention of promoting an electrical enterprise, if the conditions warranted.

This valley extends north and south, and its mountains are very rugged. It is, therefore, not affected by the heat of the sun simultaneously all day over almost its entire surface as is one that extends east and west, and the snow does not melt as rapidly in the first as in the second, so that damaging freshets are not to be feared and immense snow fields are reserved to feed its streams during the otherwise dry period.

The territory drained by the Madison River and its tributaries, available for power purposes, is 2 180 sq. miles. The minimum flow of water is 500 cu. ft. per sec.; average flow is 1 400 cu. ft. per sec.; maximum possibly 10 000 cu. ft. per sec.

The lower canyon, that near Norris, is 12 miles long and has a fall of 256 ft. in the first 8 miles. The fall of the last 4 is of scarcely any value for power purposes.

The geological formation through the canyon is black gneiss. The walls are very precipitous and, in some places, leave comparatively narrow passes for the river. In one of these, which was about 80 ft. wide at the bottom, 1½ miles from the upper end of the canyon, the site for the dam was chosen. By building a dam 236 ft. long and 57.4 ft. high at the deepest place, a reservoir was formed having an area of 4 000 acres, and a storage capacity of 44 000 acre ft., equivalent to 1 916 640 000 cu. ft.

Two years were spent in surveys, locating rights and representing claims; and about the same time in constructing a temporary wing dam and doing other preliminary work, as well as building a good flume, 10 ft. by 16 ft. inside and 1 200 ft. long, to carry water to a power house, from which electrical energy was sent 65 miles to Butte. The available head at this power house was 28 ft.

In July, 1900, the power company was organized and work was started upon a permanent dam which was to be a rock-filled

crib. Bed rock was reached across the river, except for a short distance, where two large bowlders were found. The spaces around these were cleaned as well as possible by means of steel brooms, and then filled with cement grout. The cribs are of large logs, 8 ft. centers, carefully notched together, anchored to the bottom, and driftbolted to each other. The upstream timbers are sawed to give a good nailing face for the vertical sheathing, which was 2-in. plank doubled. The seal is a concrete bed from 8 ft. to 13 ft. deep, 10 ft. wide, in which were imbedded the first logs of the crib and the lower end of the sheathing. The cribs are filled with rock as large as could be handled conveniently with a derrick — many weigh 8 to 10 tons each — and hand-placed smaller rock. All of this was blasted from the adjacent cliff, so that an excellent filling material was obtained near by and, at the same time, the upper part of the channel was widened for a spillway. There is no dirt or sand used for filling.

When this work was about two thirds of its intended height, and 140 ft. long, the company became the Madison River Power Company, with Max Hebgen, of the Butte Electric and Power Company, as supervising engineer. At this time the writer began his duties as engineer with the company.

The new management started active operation February 20, under quite adverse conditions.

The intake of the flume is on the east side of the river and the dam was started on the west side. The remaining space to be filled was, therefore, under from 1 to 6 ft. of ice which had been caused by the extreme cold weather immediately preceding, or was the channel occupied by the flume, through which it was almost necessary to carry water in order that power might be sent to the substation at Butte.

There was no material on the premises or near by, and it was evident that the remaining portion of the dam must be built before high water, or the whole structure would be likely to go out.

The plan of the original company was changed; a third layer of 2-in. sheathing was added to the face, and the base was widened to 92 ft. There are now three steps 8 ft. high and 20 ft. wide, and two steps 5 ft. high and 16 ft. wide. The first step forms the apron, the top of which is several feet above the river bed in some places, but large rocks were placed along its entire length. They did not move this season so far as we know, though the water was not high and the test not severe.

Sawed timber was used in the reconstruction work throughout. When the cribs were high enough for the deck, 10 by 10s were placed 4 ft. centers at right angles to the flow and to these was driftbolted 10-in. deck planking. The east end is a reinforced concrete block, 96 ft. long and 44 ft. high at the deepest place, and in it are the head gates and two 5-ft. square manholes. The top of this block is 4 ft. higher than the flashboards — to be described later — which insures an approach to the gate-operating mechanism even during the highest water.

The spillway over the dam, with the flashboards off, is 140 ft. wide and 10 ft. deep. There is a pipe, 11 ft. in diameter, in the concrete block, placed near the bottom to serve as a waste pipe which will discharge under a head of 28 ft., if need be, in time of flood. The feeder pipe is 14 ft. in diameter through the headblock. This pipe was intended to carry water to the old power house and operate as a pressure line. The large size was desirable, therefore, that a low velocity might be had. A change in plans whereby the power house is to be located 1½ miles down the river, available head 123 ft., has been made and the pipe line will discharge into an open tank. This being the case a high velocity is not so objectionable and the pipe has been drawn in down to 10 ft. in diameter.

Four wooden sluice gates, 3 ft. 8 in. wide and 15 ft. high, control the entrance to the feeder line; three, 3 ft. 8 in. by 12 ft., to the waste pipe. These gates slide in steel guide columns built into the concrete. Their rubbing surfaces are shod with angle iron. The leakage from the four gates controlling the feeder passed through a 2-in. hole with less than 1 ft. head of pressure. They are controlled by means of a hydraulic ram. This enables one man to operate them. They have been opened and closed almost daily since May, 1905, without a single mishap.

The screen bars are ¼ in. by 2¾ in., six to the foot, carried by channel supports.

On top of the wooden deck are the flashboards above mentioned. The frame consists of steel columns bolted to the deck, 20 ft. centers and 10 ft. high in the clear. Between the tops of these are steel girders which serve as a walk and also as a support for the tops of removable columns, 6 ft. 8 in. centers. The bottom of the removable columns rests against a foot-stop and on the top is an arrangement for lifting the column until the bottom end slips past the support, letting the flashboards go down the river, the column swinging out with the top. This method is to be used only in case of a flood so sudden and high that the flash-

boards cannot be moved beforehand, and stored upon the walk across the river. The column can then be put in place with the assistance of a traveling crane placed on the walk.

In the entire dam there are about 175 000 ft. of log, 450 000 ft. of 10 by 10; 13 500 driftbolts ¾ in. square by 18, 20, 30 and 36 in. long; 2 250 cu. yd. of concrete; 6 750 cu. yd. of rock and 100 000 lb. steel, making a structure 236 ft. long with a spillway 140 ft. by 10 ft.; discharge pipe 11 ft. in diameter discharging under a head of 28 ft.; and a pipe line feeder, 14 ft. in diameter, discharging under a head of 26½ ft.

From the dam a pipe extends 7 600 ft. to the pressure tank near the new power house. This pipe is 10 ft. inside diameter, built of 3-in. Oregon fir staves. It is encircled by ⅞-in. steel rods, 12 in. centers at the dam and decreasing in distance to 7 in. at the tank. It is supported every 5 ft. 4 in. by a steel cradle, weighing 375 lb. and is provided with two drain valves and four manholes.

The energy in a body of water 10 ft. in diameter and 8 000 ft. long, moving 8 ft. per second, would, if suddenly checked, rupture almost any pipe that can be built. Again, a sudden demand for power could not be met until the velocity had been increased and water brought 8 000 ft. from the reservoir. To avoid the first condition and eliminate, as far as possible, the second, an excavation was made in the hillside above the power house. This is an open tank; three of its walls are 2 ft. above the reservoir contour, and the fourth wall, which is the north side and also the one down stream, is level with the reservoir; hence this side can be used as a spillway for intermittent discharges during the operation of the plant and yet not materially increase the pressure on the pipe line. This tank also will have a storage capacity of 75 000 cu. ft. whereby this amount of water will be ready for immediate use in case a heavy load should come on.

The east side and north end of this tank are formed by the hillside and are rock. To insure against leakage they will be lined with cement mortar. The south end will be a concrete block through which the 10 ft. pipe enters. Provision is made for a second pipe of the same dimensions. The west wall will be of reinforced concrete, and kept from spreading out by five steel girders anchored to a channel sill at the bottom and tied across the top by means of channels to the hillside.

From this tank, which has gates similar to those in the main headblock, four steel pipes 9 ft. in diameter will lead to the

power house to feed 54-in. center discharge, horizontal, Leffel twin turbines, direct connected to general electric, three-phase, sixty-cycle, revolving field generators, running at a speed of 300 revolutions per minute and generating at 4 000 volts.

The ultimate output of the station will be 10 000 h.p. The energy will be delivered to Butte, Bozeman and other points purchasing electrical power.

CONSTRUCTION OF A POWER PLANT UNDER DIFFICULTIES.

By Edward C. Kinney, Member of the Montana Society of Engineers.

[Read at the Annual Meeting of the Society, January 13, 1906.]

A company of capitalists from Milwaukee and Chicago had conceived the idea of making fortunes by going into the western country and building an industrial city, buying the land at farm prices and selling it in city lots, and in the meantime building factories that would bring big profits and induce settlers to occupy their lands. The project for manufacturing required cheap and abundant power, and this could be had only by utilizing water power.

The site selected for this magnificent program was at Gothenburg, Neb., a small village on the Union Pacific Railway, and near the Platte River. The company bought seven sections of land around the town and many town lots. They then built a lake covering about a hundred acres of land, and a canal ten miles long to supply it with water from the Platte River.

When this part of the program had been completed, I was called upon to build the power plant, and to conduct the water to it from the lake and from it to the river.

The soil was a fine, brown, sandy loam of the general appearance of brown sugar, and of about the same consistency in water. Underlying this at a depth of from 10 to 20 ft., was a stratum of clean-washed river sand and gravel saturated with water, and extending down to the level of the river bed. From that point down indefinitely were large bowlders and coarse gravel. There is no bed rock within reach in that country, and no rock fit for building nearer than the mountains in Colorado, some 300 or 400 miles away. Bearing in mind the story of the man who built his house on the sand and the rains descended and the floods came and washed his house away, the proposition seemed a hard one.

The power house was located about 1 000 ft. from the edge of the lake in the direction of the river, and at a point where the bottom of the wheel pit would reach the level of the bottom of the river by excavating 25 ft. The length of the tailrace from the power house to the river was about a mile, and the depth of soil would require a great amount of excavation. It was desired

to do this by hydraulic work, or washing with water from the lake. This plan required the wheel pit for the power house to be built first, together with the pipe leading from the lake to the house. It would have been entirely impracticable to do the hydraulic work on the tailrace directly from the lake.

The wheel pit was nearly circular in form, 26 ft. inside diameter and 25 ft. deep, and built of stone laid in cement mortar. The location was first excavated in circular form of sufficient size and down to the level of the water, in the stratum of sand. Then was built in a circular shell or caisson of 2-in. plank placed vertically and 12 ft. high. The lower edges were beveled to a cutting edge with the sharp side out. The planks were fastened by spiking to circular forms that had been prepared and fitted in like shelves. The lower form was made of four courses of 2-in. plank cut in segments of a circle and laid with broken joints and thoroughly spiked together. The lower side of this circle was placed 18 in. above the lower edge of the vertical side plank and the whole solidly spiked together. The upper circle was made in a similar manner of two courses of plank, thus completing the form of a wooden tank or caisson without a bottom.

Within this caisson and resting on the lower shelf that had been provided for it, was built the stone wall which made the wheel pit proper. It was 26 ft. inside diameter and 25 ft. deep, with side walls 18 in. thick.

The next step was to provide a centrifugal pump with an engine to run it. The pump was fitted with an 8-in. flexible suction pipe and an 8-in. discharge and was of the kind fitted for pumping sand. The pump worked easily when the output was half or more sand and, indeed, would handle bowlders that were small enough to pass through the pipes.

The pump was mounted on the caisson so that it would follow down as the caisson settled. For the first few feet the pump simply lowered the water so that men shoveled the material into buckets and it was hoisted out in the old-fashioned way, but, as soon as there was sufficient depth of water, the shoveling ceased, and the pump was started at pumping out the sand from below the water. This worked well till we had lowered the caisson more than half way, when the lowering of the water from the inside caused such a rush of water from the outside that it brought in the sand with it, thus making a great amount of extra work. To counteract this, water was brought from the lake through the supply pipe, that had in the mean time been built,

and poured into the pit, so that no matter how much we pumped out, the water was higher inside than out, and there was no tendency of the sand to flow in.

In excavating, the suction pipe was moved around over the bottom of the pit under water, and as the material was removed the caisson settled down to its place. In building the walls of the caisson, arched openings had been built for the outflow of the water from the wheels when in operation.

The plan of the power house showed two pairs of horizontal turbine wheels set on steel frames across the top of the wheel pit, with draft tubes extending down nearly to the bottom of the pit, and discharging under water. The wheels were fed by a great pipe leading to them from the lake. This would mean a great amount of water falling from a height into the bottom of the pit, and this being of soft sand, would speedily wash out unless a solid bottom was put in.

This was done in the following manner: There being 15 ft. of water in the bottom of the pit, it was necessary to build the bottom at the top of the water and lower it down. A timber platform was made of three courses of 3-in. plank crossed and spiked together. This was circular in form and 1 ft. less in diameter than the pit, to be sure that it would pass any projecting rock in the walls. The platform was suspended at the surface of the water by three long rods extending up through the timbers that had been placed across the top of the walls. Each of the rods had been threaded for 15 ft., and had a large nut and washer at the lower end of the threaded portion, so that when the nuts were unscrewed the suspended bottom would sink into place.

A course of masonry 18 in. thick was laid in cement on the platform, and when dry was lowered by a man at each rod unscrewing the nuts in unison. The bottom having been made a foot less in diameter than the pit, there was an opening 6 in. wide entirely around the wall, and to make a complete and safe job this had to be filled with concrete, and being under 15 ft. of water, some unusual plan had to be devised.

It was found by experiment that a strong stream of water was flowing up from below through the opening between the bottom and side walls so that ordinary concrete would be washed out before it could set. To overcome this, there were made long sacks of cotton cloth about 8 in. in diameter, so that when filled and pressed down in the bottom of the opening they would completely fill it. These sacks were filled with dry concrete

and placed end to end in the opening and pressed down solidly with timbers. A second course of sacks was placed above the others so as to make the bottom surely tight. The remaining space was filled with loose concrete and as that had to be passed down through the water a way had to be found whereby it might be placed without having the particles of cement washed out of the sand.

This was accomplished by taking a seamless grain sack and splitting open the bottom; the bottom was then turned up some 8 in. and a small opening made through both parts; this was passed over a loop that had been fastened on the front of the sack and a wooden pin passed through. A small rope was attached to the pin with which to withdraw it when the sack was in place. Then when a small rope had been attached to each of the upper corners of the sack it was ready for service. To operate the device, the bottom is turned up and fastened on the loop with the pin, the sack is filled with dry concrete and lowered down through the water to the desired location. With a pull on the pin, the bottom opens and a careful lifting of the sack permits the concrete to fall out exactly in its final position without having been washed by falling loosely through the water. In this way the remaining space between the bottom and side wall was completely filled and piled up against the side to a slope of 45 degrees.

Having completed the inside, we turn to the outside. On the side of the pit towards the lake and for two thirds of the way to the front, the earth remains nearly to the top of the pit, but for the one third on the front, or outlet side, it is to be cut away to the level of the outlet windows, or nearly to the bottom of the pit. The material beneath the pit being nothing but sand and gravel there is extreme danger of its washing out when the great flow of water comes, and permitting the foundation walls to fall out. The back two thirds of the wall being covered with earth and away from any wash is safe; to make the front wall safe it was determined to build a concrete foundation below and in front of it. This was accomplished in the following manner: thirty pieces of $1\frac{1}{2}$-in. pipe, 20 ft. long, were provided, and a strong stem force pump with a 50-ft. section of hose. The hose was coupled on to the pump and one of the pipes. The pipe was set up on end, in the sand, and a stream of water started through it. As the stream washed the sand away from the bottom, the pipe settled down rapidly till the whole pipe was down as far as desired. The hose was disconnected and attached

to another pipe and it was put down till all were in place. They were set $2\frac{1}{2}$ ft. apart, each way.

In making concrete it is only necessary to have sand, gravel, water and cement, and, as the first three were in place, it only remained to supply the cement. To accomplish this, an arrangement of pipes and valves was made, with one large pipe connected in, that would hold a bucketful or more of cement. This was connected on top of the first pipe and to the pump by the hose. The pump started a stream of water through the straight part of the pipe into the sand below, then a charge of cement was placed in the receptacle and the valves changed so that the stream would pass through the charge carrying it down and spreading it through the sand at the bottom of the pipe. As soon as a charge was spread, the flow of water was changed back to the straight pipe and another charge of cement placed in the receptacle. The whole pipe was lifted a few inches and the cement again distributed through the sand. This operation was repeated until the pipe was worked out, and continued with the other pipes till all had been worked, when the pipes were reset and the operation had covered the desired ground. In this way we put 55 barrels of Portland cement into the sand below and built a block of concrete 10 ft. wide, 8 ft. deep and 35 ft. long around the front of the wheel pit.

After completing this preliminary work, the excavation of the tailrace was comparatively easy. A small ditch was first excavated with teams to give the channel the proper course. After that, the bottom of the race was plowed, a strong stream of water turned in from the lake through the power house, and the loose material washed out; then the proceeding was repeated till the whole was complete and at vastly less expense than to have done it all with scrapers.

The power house was built with one end resting on the wheel pit and the other on piles that had been driven solidly into the soft material that has been described.

The pipe leading from the lake to the power house was built of wooden staves and steel bands and was 6 ft. in diameter. It rested in a trench that had been dug for it in the earth and was covered with 2 ft. of earth.

The plant developed 500 h. p., which has been utilized for city lighting, running two flour mills and several elevators. The plant has been running successfully for twelve years, but the plan for a great city fell by the wayside.

SEWAGE DISPOSAL AT MANCHESTER AND BIRMINGHAM.

By Leonard Parker Kinnicutt, Member of the Boston Society of Civil Engineers.

[Read before the Society January 24, 1906.]

On my return from England last autumn, I was asked by the Executive Committee of the Sanitary Section of the society to give an account of the present status of the sewage purification plants at Manchester and at Birmingham, one being a typical example of the contact bed treatment, the other of the percolating filter process.

I consented only on one condition, — that what I had to say should not be in the form of a written paper, but in the form of an informal after-dinner talk, using for my material only the data I had obtained at the time of my visit, or in personal correspondence with Dr. Fowler and Mr. Watson. I am, therefore, not going to give any careful or complete description of either plant, which would be an old story, but only a talk that may answer certain questions that you would be likely to ask when visiting these two plants.

The population of the sewer district of Manchester is 600 000, and the dry-weather flow of sewage is calculated as being about 29 000 000 gal., with a storm water flow of about five times that amount.

The general plan of the sewage plant is as follows: Four settling tanks, capacity of each 1 630 000 gal.; 12 septic tanks, total capacity of 19 500 000 gal.; 92 first contact beds, each 0.5 acre superficial area, constructed of cement concrete and filled with furnace clinker rejected by a 1.5 in. mesh passed by a 0.25 in. mesh to a depth of 40 in. Besides these 92 first contact beds there is an area of 27 acres divided into 29 storm-water contact beds. In these beds the filling material, 2.5 ft. of unscreened furnace clinker, rests generally upon a heavy clay marl, though where needed a layer of cement concrete has been laid down. They are designed to operate at a rate of 3 000 000 gal. per acre per 24 hr. The original plan also included 52 half-acre second contact beds similar in construction to the first contact beds, except the filling material was to be somewhat finer; as yet, however, only one has been constructed.

At the present time the whole of the septic tank instalment

not being completed, part of the sewage, 40 per cent., is being treated chemically (lime and iron sulphate), and 60 per cent. by septic tanks. All of the sewage, both that chemically treated and that passed through septic tanks, is in dry weather carried to the contact beds; in wet weather the excess is treated on the storm beds.

The amount treated on the contact beds averages 600 000 gal. per acre per day. The effluent is, however, not perfectly satisfactory, often undergoing secondary putrefaction, and there is no question that to obtain uniformly satisfactory results this effluent must be treated on second contact beds.

At the present time 600 000 gal. of the effluent of the first contact beds is passed on to the one second contact bed (0.5 acre area) that has been built. The effluent from this second contact bed has so far been non-putrescible.

Allowing that a satisfactory effluent can be thus obtained, it requires for the satisfactory treatment of 600 000 gal. per day 1.5 acres, or one acre for 400 000 gal., and this is the figure that is now given by Mr. Fowler.

As regards the permanency of contact beds the original anticipations have not been fulfilled. The first contact beds at Manchester were put into commission in 1901. To-day these first beds are clogged to such a degree that it has been found advisable to remove the filling material, wash it, make good the waste and refill the beds. The greatest amount of clogging has taken place over the underdrains, and in some of the beds only the portion of the filling material over these drains is being removed, in other beds the whole material.

As to the cost of contact beds, Mr. Fowler kindly gave me the following figures: Original cost per acre, including excavation, underdraining, laying of the cement concrete and filling material in place, $13 000.

The filling material laid in place cost 87 cents per cu. yd. The cost of removal of this filling material this past year, washing it and replacing it was, when the whole bed was done, 31 cents per cu. yd. When the whole of the filling material of the bed was not taken out, but only those portions which had been badly broken down and clogged, it cost 41 cents per cu. yd. In neither case did this include the cost of new material to make up for that lost in the washing and sifting. The amount of material thus lost was large on account of the softness of the furnace clinkers originally used, and the replacement of lost material cost about 31 cents per cu. yd. This makes the cost of

Fig. 1. Dortmund Tank. Used at Birmingham for Removing Suspended Matter from the Septic Tank Effluent.

Fig. 2. Construction of the One-Acre Percolating Filter at Birmingham.

reconstruction of the beds, with the washed and sifted material and new material, 71 per cent. of the original cost of filling material laid in place. The filling material, however, in these reconstructed beds is much better than the original material, as it is only the hardest and best portions of the original material that have been now placed in the beds, the softer portions being the part that was lost in the washing and sifting.

If we turn to Birmingham we find that the population of the drainage area is about 793 000, — 200 000 more than Manchester, — and that the total dry weather flow of sewage, 30 000-000 gal., is about the same as Manchester, the storm weather flow from 6 to 9 times the dry weather flow.

The Birmingham sewage is, however, a stronger sewage than Manchester sewage, albuminoid ammonia averaging 1.69 against 0.52 for Manchester; oxygen consumed 27.48 against 10.54 parts per hundred thousand parts. At both Manchester and Birmingham the preliminary treatment will, when the changes contemplated at Manchester are completed, be practically the same, — sedimentation and septic tanks. From that point the treatment is radically different, for, as we have seen, Manchester treatment is by contact beds, while Birmingham is by percolating filters. The general plan of the sewage plant at Birmingham is as follows:

There are 5 settling tanks and 20 uncovered septic tanks situated at Saltley. The settling tanks, each divided into three compartments, have a total capacity of 6 000 000 gal. The mean rate of flow of sewage through the tanks is 1.2 ft. per min., giving 4.36 hr. for sedimentation. The total capacity of the septic tanks, which average 8 ft. in depth, is 8 700 000 gal., giving 8 hr. for septic action. The effluent from these tanks, according to the present plan, is to flow in a closed conduit, 5 miles long, fall 2 ft. per mile, to Sutton Coldfield, where the percolating filters are situated.

At the present time only a portion is thus carried, the rest being flowed upon the land at various points. At the end of the conduit there is a large intake chamber from which the flow can be automatically regulated and delivered into settling tanks to remove a large part of the suspended matter which is contained in the effluent from the septic tanks as delivered at Sutton Coldfield.

These tanks, 5 in all, are of the Dortmund type. They are 44 ft. in diameter and 33 ft. 6 in. deep from coping level to bottom of the sump, the lower portion being in form of an

inverted cone having a batter of 1 to 1. The opening of the inlet pipes varies at the present time in the different tanks from 15 ft. 9 in. to 19 ft. 9 in. below the water level, the best depth having not as yet been determined. The combined capacity of these tanks is 810 400 gal., normal flow 42 170 gal. per hr., which gives an upward velocity through the cylindrical portion of the tank of 4.4 ft. per hr. and a sedimentation of 4 hr. These tanks remove, as shown by analyses, about 75 per cent. of the suspended matter contained in the septic tank effluent. From these settling tanks the clarified sewage is delivered on the percolating filters. Of these there are, at the present time, four experimental 0.25 acre circular beds, one 0.5 acre and five 1-acre rectangular beds. To these are to be added 10 more 1-acre rectangular beds, 3 of which are nearly completed, making it by far the largest plant of this description yet built. In addition, 30 acres of storm-water filters, to be built on the percolating system, have just been sanctioned by the Tame and Rea District Drainage Board.

The acre beds are all built on the same general plan, rectangular in shape, side walls of cobble, laid dry, bottom of concrete, fall about 9 in. across bed. The concrete is covered with an aërating floor of semicircular stoneware tile, laid loose jointed, on which the filling material, broken quartzite, fist size, is placed. The effluent from the silt tanks is discharged by means of fixed sprinklers, each bed being divided into 8 bays, each bay being independently supplied with clarified sewage by an 8-in. pipe.

The drainage from these beds is to be discharged into humus tanks of the Dortmund type so as to remove the so-called "humus" from the effluent before it is run upon the land.

As to the amount of sewage treated by the percolating beds, Mr. Watson has made careful measurements of the amount of sewage applied to each bed each week and in a letter dated January 1, 1906, he says: "I am now in a position to say definitely that the amount satisfactorily treated by our beds is about 750 000 gal. per acre per day, which is about 900 000 U. S. gal."

As to the cost of percolating beds, he says: "The cost of our bacteria beds, including all supply pipes, effluent channels, distributing pipes, filling material, etc., is between \$29 000 and \$31 500. The cost of the broken stone is \$1.48 per cu. yd. delivered, to which must be added 12 cents per cu. yd. for conveying to and filling the bacteria beds, which gives a total of \$1.60 per cu. yd."

As to the life of a percolating filter, Mr. Watson says: "Though believing that after use for a given period the filling material will have to be washed, and that such beds will not last forever, the period that a percolating bed will run before washing the material becomes necessary is still an unknown quantity. Personally, I believe that such a bed will run very much longer than a contact bed, allowing the same careful supervision in both cases."

As to the relative cost, in England, of contact beds and percolating filters, taking the data given by Dr. Fowler in one case, and that given by Mr. Watson in the other, the following comparison can be made: Original cost of well constructed contact beds, filling material, graded furnace clinker, $13 000 per acre.

Original cost of equally well constructed percolating filters, filling material, crushed stone, fist size, $30 000. Amount of sewage that can be satisfactorily treated by contact beds, 400 000 imperial or 478 000 U. S. gal. per acre per day.

Amount that can be treated by percolating filters, 750 000 imperial or 896 400 U. S. gal.

Cost, calculated per unit capable of treating one million U. S. gallons daily, contact beds, $27 196; percolating filters, $33 470.

Dr. Fowler's figures are, however, for contact beds filled with furnace clinker; Mr. Watson's for percolating beds filled with broken stone, and even if the life of the percolating filter is no longer than that of the contact bed, the material lost in washing and sifting when the beds are reconstructed must be much greater with furnace clinker than with broken stone.

The work accomplished by the various portions of the plant at Birmingham, as also has been the case at Manchester, has been studied in the most careful and thorough manner, and the tables of analyses printed below, those of Birmingham given to me by Mr. Watson and printed by his permission, those of Manchester derived from the annual report of the Rivers Department of the city of Manchester, are the results obtained by daily analyses of samples collected so as to give, as nearly as possible, the true composition of the sewage and of the effluents.

The effluent from the percolating filters, except that it contains suspended matter, is said to be perfectly satisfactory, and to be non-putrescible, as is indicated by the amount of nitrogen as nitrites and nitrates it contains.

It is interesting to note that as the result of the experiments at Columbus, percolating filters have been adopted for the treatment of the sewage of that city, and in many particu-

lars the proposed method is very similar to the plan as worked out by Mr. Watson. Capacity of plant at Columbus, 20 000 000 gal. per day. Six septic tanks, 4 primary and 2 secondary, total capacity 8 020 000 gal. Period of sedimentation, 8.5 hr. Period of sedimentation at Birmingham, about 12 hr.

At Columbus, 4 percolating beds, each 2.5 acres, total area 10 acres. Rate of flow on beds, 2 000 000 gal. per day. Rate of flow on percolating beds at Birmingham, 900 000 gal.

Taking the difference in strength between Birmingham and the average American sewage, the rate of flow on beds may be considered as practically the same.

The chief difference in the two plants is that at Columbus the tanks for collecting the suspended matter in the septic tank effluent are omitted, and that at Columbus the beds are to be treated with 4 000 000 gal. per acre per day for 2 weeks, and then allowed to remain at rest for 2 weeks.

Table of Analyses Showing Effect of Treatment of Manchester Sewage on Contact Beds, Rate 600 000 Gallons, and of Birmingham Sewage on Percolating Beds, Rate 900 000. Manchester Results for the Year Ending March 30, 1904; Birmingham, for the Year Ending January 1, 1905.

MANCHESTER.

Parts per 100 000.

Source of Sample.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrites and Nitrates.	Oxygen Consumed.
Crude sewage..........	2.27	0.52	....	10.54
Septic tank effluent.....	2.63	0.37	....	9.35
Contact bed effluent....	1.62	0.15	0.27	2.72

Average purification: On albuminoid ammonia basis, 71 per cent.
On oxygen consumed basis, 73 per cent.

BIRMINGHAM.

Source of Sample.	Free Ammonia.	Albuminoid Ammonia.	Nitrogen as Nitrites and Nitrates.	Oxygen Consumed.
Crude sewage..........	4.28	1.69	1.05	27.48
Septic tank effluent.....	4.16	0.71	0.46	15.28
Percolating bed effluent.	3.39	0.27	2.20	2.57

Average purification: On albuminoid ammonia basis, 84 per cent.
On oxygen consumed basis, 90 per cent.

Running percolating beds in this manner is new and the result will be watched with interest.

In conclusion I do not for one moment wish it to be thought that I believe that either contact or percolating beds are advisable when the process of intermittent sand filtration can be used, for I think there is no question that where sand soil can be obtained or sand procurable at a permissible price, as is usually the case in New England, the method of intermittent filtration is by far the best of all biological methods.

TABLE OF ANALYSES SHOWING AVERAGE COMPOSITION OF SEWAGES AND EFFLUENTS FROM THE PURIFICATION WORKS OF THE BIRMINGHAM TAME AND REA DISTRICT DRAINAGE BOARD, DURING THE YEAR 1904.

PARTS PER 100 000.

SOURCE OF SAMPLE.	SUSPENDED SOLIDS. Total.	SUSPENDED SOLIDS. Volatile.	Free Ammonia.	Albuminoid Ammonia.	Chlorine.	Nitrogen as Nitrites and Nitrates.	Oxygen Consumed.
Crude sewage	77.9	49.4	4.28	1.69	19.8	1.05	27.48
Septic tank effluent	35.0	23.2	4.16	0.71	19.6	0.46	15.58
Silt tank effluent	8.1	4.7	6.68	0.55	19.5	...	12.00
Percolating filter effluents							
Bed *A*	4.6	...	0.98	0.16	17.7	3.36	1.62
Bed *B*	1.1	...	3.89	0.36	18.3	1.70	3.61
Bed *C*	5.6	...	2.38	0.24	17.9	2.74	2.36
Bed *D* (1) fine material	1.6	...	2.99	0.17	18.3	2.28	1.82
Bed *D* (2) coarse material	2.8	...	5.58	0.37	19.5	2.04	2.03
Bed *E*	7.6	...	2.33	0.22	18.5	2.27	2.57
Bed 8	2.8	...	5.57	0.37	19.5	0.85	3.96

A. One-quarter acre circular bed. Filling material, graded furnace slag, 6 in. at bottom of bed, .75 in. at top. Walls of bed of same material. Not underdrained. Mather & Platt distributer.

B. One-quarter acre circular bed. Filling material, graded gravel. Walls of cobble. Underdrains of semicircular tiles. Adams distributer.

C. One-quarter acre circular bed. Filling material, graded broken brick, 3 in. at bottom, 0.5 in. at top. Underdrained. Walls of brick. Scott-Montcrieff distributer.

D. One-quarter acre circular bed. Divided into two portions to test difference in action of coarse and fine material.

D (1). Broken quartzite, size 2.5 in. at bottom, 1.5 in. at top.

D (2). Broken quartzite, 0.75 in. diameter. Underdrains semicircular tiles. Whittaker distributer.

E. One-half acre rectangular bed, constructed below ground level Floor of concrete, fall 1 in 240, covered with semicircular stoneware tiles. The sides of the beds are excavated to the level of the floor and sloped back to give free circulation of air. The filling material is laid to

a depth of 6 ft. and consists of screened clinkers from the gas works, the lower 3 ft. being from 3 to 6 in. in diameter, the remainder passed through 1.5 in. screen. Sewage distributed by fixed sprinklers.

8. One acre rectangular bed. Walls of cobble, laid dry. Filling material, broken blue brick, 2.5 ft. of fist size, 1 ft. of 1.5 in., 1 ft. of 1 in., and 6 in. of 0.5 in. gage. Floor cement concrete, fall 9 in. across bed covered with aërating floor of semicircular tiles, laid loose jointed. Sewage distributed by fixed sprinklers.

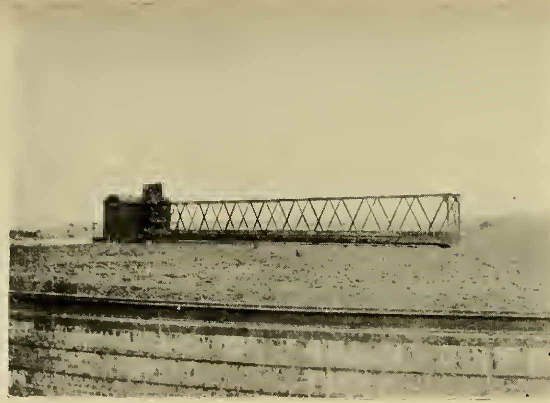


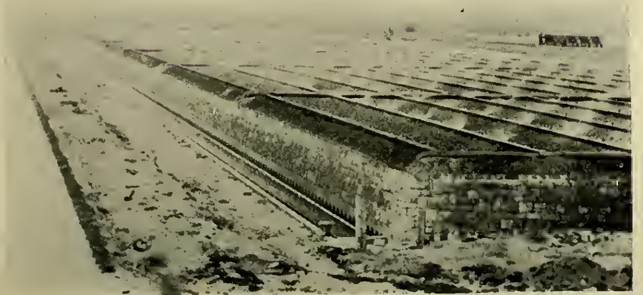
Fig. 7. One-quarter Acre Experimental Percolating Bed, Birmingham, Scott-Montcrieff Distributer, known as Bed C.

Fig. 9. One-quarter Acre Experimental Percolating Bed, Birmingham. Walls of Dry Cobble.

Fig. 4. One-quarter Acre Experimental Percolating Bed at Birmingham, Adams Distributer, known as Bed B.

Fig. 8. Underdrains of the Acre Percolating Beds, Birmingham.

Fig. 5. Construction of the One-acre Percolating Beds at Birmingham.



… cre Percolating Beds at

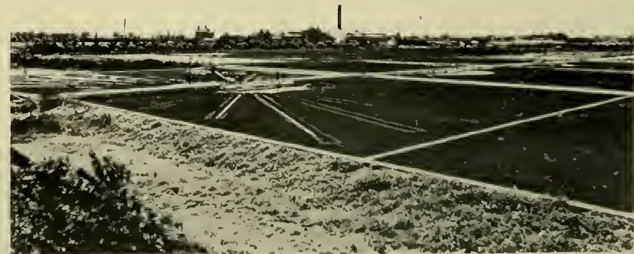


Fig. 3. Contact Beds at Manchester.

Editors reprinting articles from this Journal are requested to credit the author, the Journal of the Association, and the Society before which such articles were read.

Association of Engineering Societies.

Organized 1881.

VOL. XXXVI. APRIL, 1906. No. 4

This Association is not responsible for the subject-matter contributed by any Society or for the statements or opinions of members of the Societies.

THE OPERATION OF SEWERAGE WORKS.

OPERATION OF THE SMALL SEWAGE FILTERS AT LAKE KUSHAQUA, N. Y.

By Robert Spurr Weston, Member of the Boston Society of Civil Engineers.

[Read before the Sanitary Section of the Society, March 7, 1906.]

At the Stony Wold Sanatorium, Lake Kushaqua, N. Y., — an institution for the care of women suffering from tuberculosis,— the writer has installed a sewage disposal plant consisting of a septic tank, dosing chamber, sludge bed and two disposal beds. The septic tank has a capacity of 15 000 gal. The two sewage beds have an area of 0.22 acre, and each bed is used on alternate days.

The sewage is applied to the bed in doses by means of an automatic siphon. From three to five doses are applied to each bed daily, at the rate of about 135 000 gal. per acre per diem, or an average rate of 68 000 gal. per acre per diem. The area takes care of the sewage of about 125 people, and is designed to care for 200 people.

The cost of the plant was rather high, the work being performed under difficulties. The beds were excavated in hardpan gravel, and most of the filling was hauled from a point 100 yards distant. The beds cost $8 450 per acre, and the septic tank cost $121 per thousand gallons' capacity.

No difficulty has been experienced in the operation of the beds, nor have they been a nuisance to the sanatorium, only 1 200 ft. distant. During the winter the beds have been covered

with several feet of snow, yet they have been operated without interruption.

The only difficulty experienced has been due to growths of algæ on the surface of the beds during the summer months. These growths have made more frequent scraping necessary. For example, during 1905, the beds were scraped three times during the open season. These algæ form a blanket over the bed and cause the filters to clog more rapidly than is usual. These algæ grow on the surface of the bed only. None are apparent where the effluent from the filters enters the lake. The cause for these algæ is not apparent. They are not the result of pools of water formed on the surface, but are rather the cause thereof.

THE SEWAGE FILTRATION PLANT AT THE CONTAGIOUS HOSPITAL, BROOKLINE, MASS.

By Alexis H. French, Member of the Boston Society of Civil Engineers.

[Read before the Sanitary Section of the Society, March 7, 1906.]

The hospital consists of five buildings, in addition to a laundry and a building of temporary character for smallpox patients. It is situated in the south part of the town, on a watershed tributary to the Neponset Valley sewer of the Metropolitan Sewer System. The trunk sewer of this system has been extended to the town line, but as it seemed improbable that there would be general call for its extension to the region in which the hospital is situated for many years, it was thought best to devise some other method of disposal.

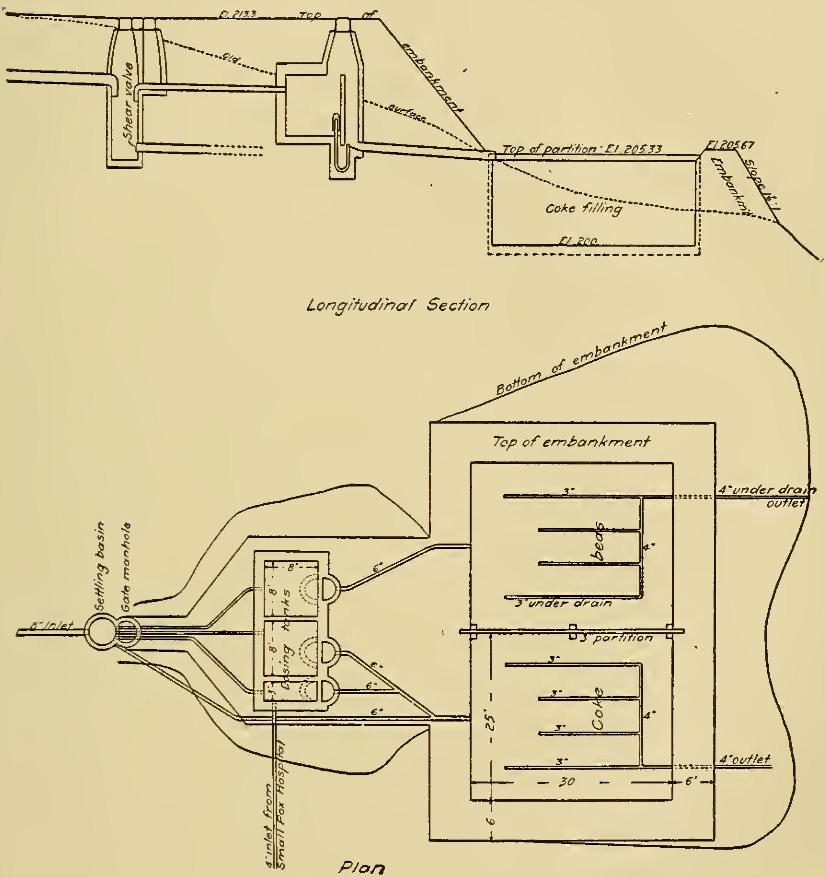
The land on which the hospital is located is rough and irregular and consists of a comparatively light depth of clayey soil overlying conglomerate ledges. The surface drainage is into swampy ground not owned by the town, some 40 ft. below the hospital buildings.

On the advice of Mr. Goodnough, engineer of the State Board of Health, it was concluded that the sewage would be sufficiently purified to permit the effluent being discharged into the low land above referred to, if the sewage were filtered through underdrained beds of coke breeze 5 ft. in thickness.

The hospital was designed for a maximum population of 70. On a basis of a water consumption of 100 gal. per capita per day, we have 7 000 gal. daily as the maximum

amount of sewage requiring disposal. Allowing for a maximum rate of filtration of 200 000 gal. per day per acre, we have 1 500 sq. ft. as the required area for the beds, which area was provided in the plan adopted.

On account of the varying number of patients, and in order



that the dosing tanks should discharge once daily under all the varying conditions which may arise, three tanks were built, of the dimensions shown on the accompanying sketch.

The hospital has been occupied since October, 1902, and the method of disposal has been practically free from objection, although it should be said in passing that the hospital buildings are the only ones within 400 ft. of the beds. The coke used

ranges from ¼ in. to ¾ in. in diameter and appears to be well adapted for the purpose.

The Miller siphons failed to do the work for which they were installed, and one of them has been replaced by a Dececo. The others will shortly be replaced. With this single exception, the plant, as designed, has given satisfaction from the start.

SEWAGE DISPOSAL PLANT AT THE STATE COLONY FOR THE INSANE, GARDNER, MASS.

By J. J. Van Valkenburgh, Member of the Boston Society of Civil Engineers.

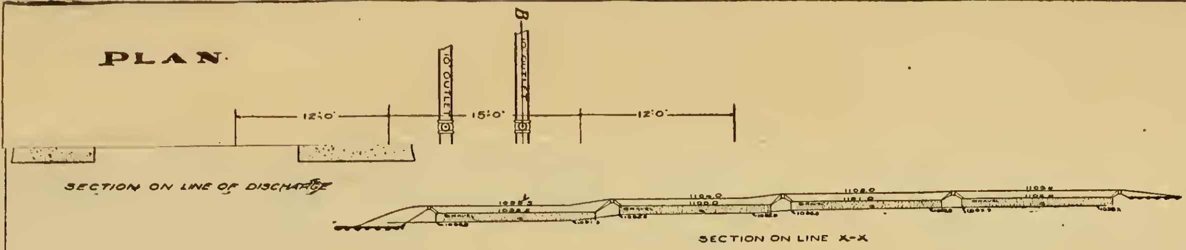
[Read before the Sanitary Section of the Society, March 7, 1906.]

The State Colony for the Insane is located in Gardner, near the Fitchburg Division of the Boston & Maine Railroad, about 2½ miles south from South Ashburnham.

The area owned by the State comprises about 1 800 acres of rough land, on which it is proposed to employ the chronic insane patients taken from the state insane hospitals. At present the administration buildings only have been constructed and the number of inmates is about 275, but it is proposed eventually to provide for a much greater number. There is no sandy or gravelly soil within a long distance of the buildings, the soil being chiefly clay and hardpan, so that it is impossible to purify any considerable quantity of sewage upon the natural soil. It was decided, therefore, to construct artificial filter beds, and after obtaining estimates for filtering material of various kinds, it was determined to make the beds of sand brought from Fitchburg by the Boston & Maine Railroad.

The buildings are so located that it was possible to select a very desirable location for the filter beds, about 1 200 ft. from the buildings, in a secluded spot sheltered on three sides by a grove of trees. The sewage is conveyed to the filtration area through an 8-in. pipe which discharges into a small settling tank designed to remove only the heaviest portions of the sewage. From the settling tank the sewage passes into a dosing tank, from which it is discharged intermittently upon the filter beds.

The settling tank has a capacity of 7 472 gal. and the solid matter which accumulates in it is discharged upon one of the filter beds which is reserved for this purpose. There is a connection between the settling tank and the dosing tank which



PLAN OF

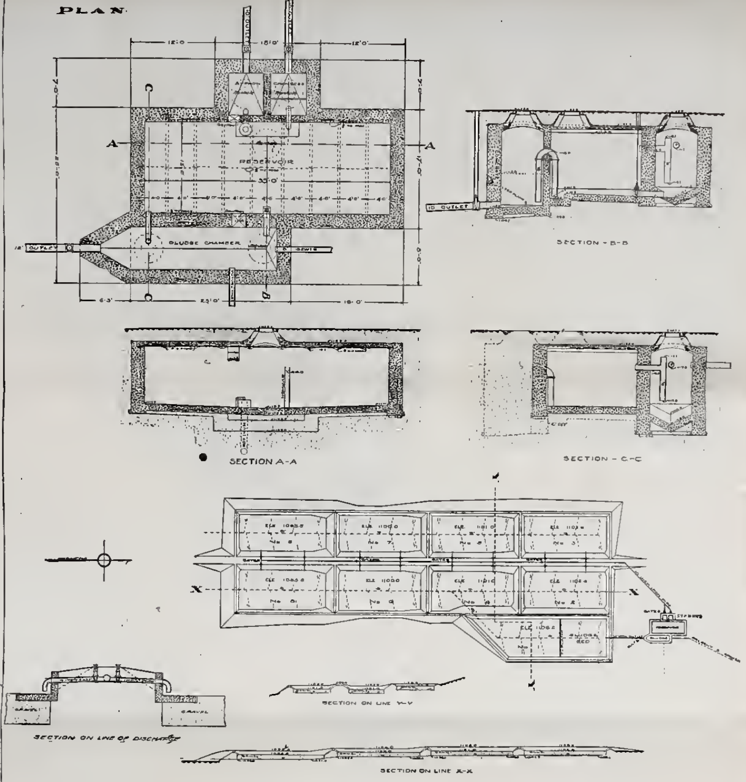
RESERVOIR AND FILTRATION AREAS

STATE COLONY FOR THE INSANE.

GARDNER MASS.

MAY 1904

J J VAN VALKENBURGH, C E



PLAN OF

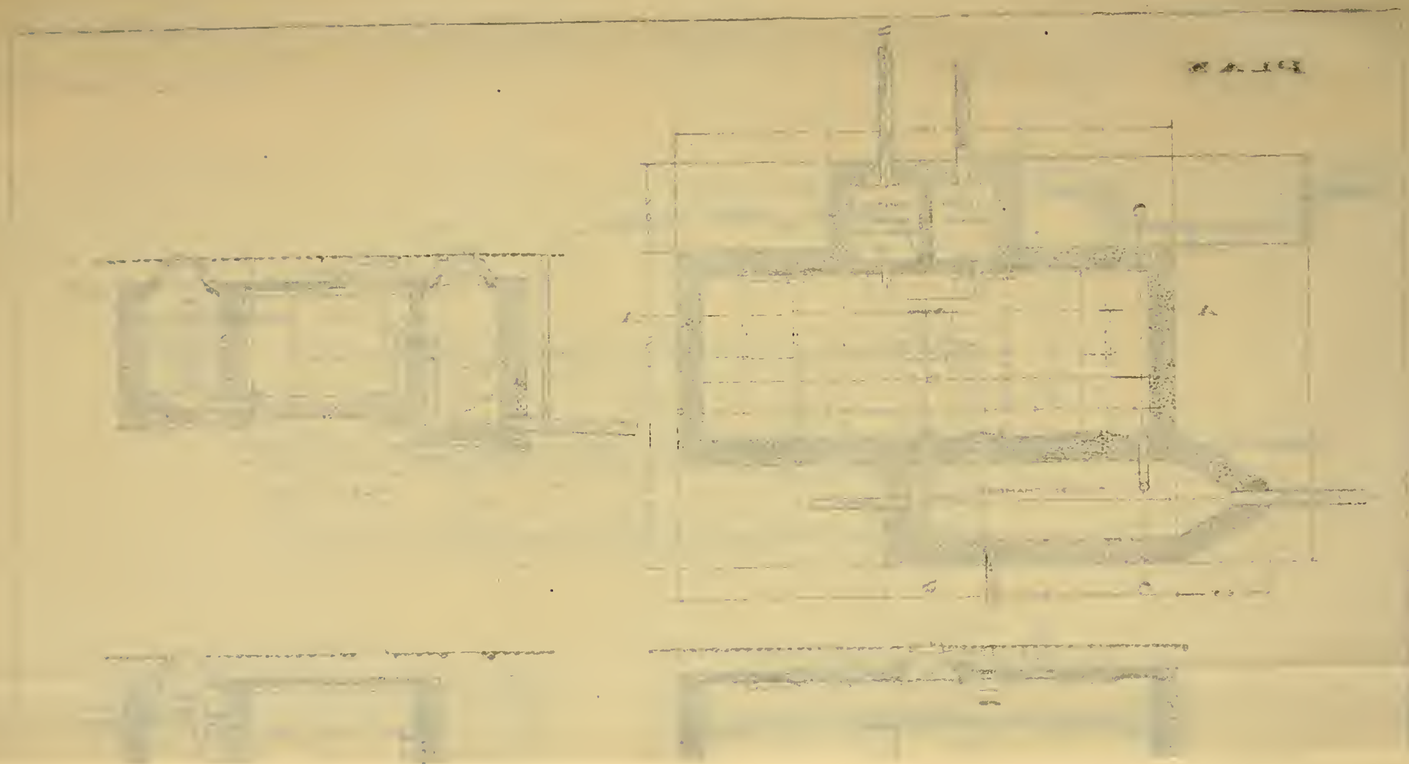
RESERVOIR AND FILTRATION AREAS

STATE COLONY FOR THE INSANE.

GARDNER MASS.

MAY 1904

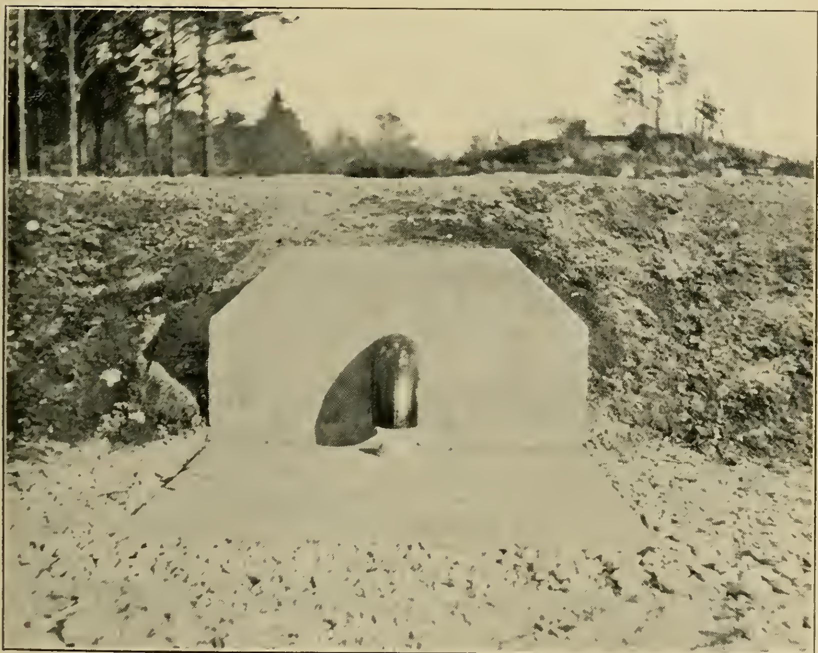
J J VAN VALKENBURGH, C.E.



Preparing System of Underdrainage.

Receiving Filtering Material.

Discharging upon Sludge Bed.



6-inch Outlet.

permits the rapid discharge of the contents of the latter through the former for the purpose of flushing out the heavy solid matter. The dosing tank has a capacity of 17 474 gal., sufficient to flood one of the filter beds to a depth of about 3 in. It is provided with a simple form of siphon, the construction of which is shown on the accompanying plan.

The filter beds which receive sewage from the dosing tank are 8 in number, each 100 ft. long and 50 ft. wide on the center lines of the embankments, making a total area of about one acre. The beds are on each side of a central embankment which is of sufficient width to form a roadway. The sewage is conveyed to the beds through a 10-in. cast-iron pipe laid in this central embankment with two 6-in. outlets on each bed. Each outlet is provided with an ordinary water gate. The sewage discharges through a quarter-bend so placed as to discharge the sewage downward upon a concrete apron. Immediately beneath the opening in the pipe is a conical-shaped mound of concrete so constructed as to cause the sewage to spread out equally in all directions.

The sludge bed, which is designed to receive the contents of the dosing tank, has an area of about 5 000 sq. ft. and is similar in construction to the other beds. A plank is placed across the center of the bed which intercepts the heaviest portions of the sludge, and the material which flows over the plank to the other half of the bed consequently contains much less solid matter, so that it is necessary, ordinarily, to clean only one half of the sludge bed.

The soil where the beds are located consists of clay with many bowlders, and the area in the beginning was very rough and covered with trees, stumps and bushes. The area was first cleared of stones and roots and leveled to receive the sand, the embankments being formed with the material removed in the process of leveling. The embankments were held in place by planks which were removed as soon as there was sufficient sand in the beds to hold them.

The underdrains were laid before the filtering material was placed. The main underdrains are 6 in. in diameter, with a fall of 6 in. in each bed. The laterals are 3 in. in diameter. The depth of the underdrains is from 4½ ft. to 5 ft. beneath the surface of the filtering material. The joints of the pipe were wrapped with muslin and 6 in. of crushed stone were deposited over the drains. This was followed by 3 in. of clean screenings. The crushed stone around the drains was held in position by

planks which were removed when covered by the filtering material. (See photographs.)

The central embankment is 8 ft. wide on top and all other embankments are 2 ft. in width. The tops and slopes of all embankments were covered with 6 in. of loam and were seeded.

The sand used for the filtering material was furnished by the Boston & Maine Railroad Company from a pit about 1½ miles east of the Fitchburg Railroad depot. The railroad company built a spur track from the main line to the beds, the track ending on the central embankment between the two rows of beds, — a distance of about 2 400 ft. from the main line of the railroad.

The price paid to the railroad company for the sand was 70 cents per cu. yd. This price included the cost of building and removing the spur track; changing the location of the track from time to time to accommodate the necessities of the work, and the material was furnished when and where wanted. The round trip from the pit to the filtration area was about 28 miles, and when required the company delivered 3 train loads per day with 7 cars on the train, each car holding 20 cu. yds. The contractor received 40 cts. per cu. yd. for excavation, which included the building of the embankments, and 19 cts. per cu. yd. for unloading the sand from the cars and putting the same in place; 20 cts. per ft. was paid for furnishing and laying the 6-in. underdrain and 14 cts. per ft. for the 3-in. lateral drains. The State furnished the crushed stone, but the contractor at his own expense hauled it 1 200 ft. The total cost of the filter beds complete was $9 966.82 or $13 280. per acre of filtering surface or about $8 500 per acre of filter beds measured on the center lines of the embankments. The cost of the settling and dosing tanks was $2 400, making the total cost of the plant $12 366.82.

THE SEWERAGE SYSTEM OF THE HYANNIS STATE NORMAL SCHOOL.

By George H. Wetherbee, Jr., Member of the Boston Society of Civil Engineers.

[Read before the Sanitary Section of the Society, March 7, 1906.]

In the year 1897, a state normal school was opened at Hyannis, a town very prettily located on Cape Cod, 72 miles

south of Boston, and at that time a water plant and a sewerage system were established.

The sewerage system was to take care of the sewage from the school building and the dormitory, the latter to accommodate about 60 students. The system then put in consisted of a 4-in. pipe taking the sewage from the two buildings southerly across South Street to a cesspool situated on the slope of the hill, with an overflow 5 ft. from the bottom, extending to two roughly prepared filter beds built one above the other, differing in elevation by 1.4 ft. By means of a wooden spout, sewage could be conducted to either bed.

In the spring of 1901, I had an invitation from Mr. Baldwin, the principal of the school, to look the ground over with the idea of rearranging the system. I found the sewage flowing slowly from the cesspool on to the filter beds, emitting an offensive odor. Complaints had been made by dwellers in the immediate neighborhood because of these odors and the unsightliness of the beds. After making some surveys and a careful study of the surroundings, I decided to locate a new filtration area about 200 ft. easterly from the old beds, where sand of a very good quality was found, and to distribute the sewage upon this area through pipe laid 2 ft. beneath the surface. Owing to the fact that the Summer School followed closely the ending of the regular school year, the old system could not be disturbed, so I planned to connect the new pipe line with the old sewer at a manhole just north of South Street, following nearly the line of the old sewer to a reservoir. This reservoir has a capacity of about 630 gal., or about $\frac{1}{6}$ of the daily flow, and when filled discharges automatically through a 5-in. Miller siphon into an 8.-in. pipe through which it flows to the filtration area.

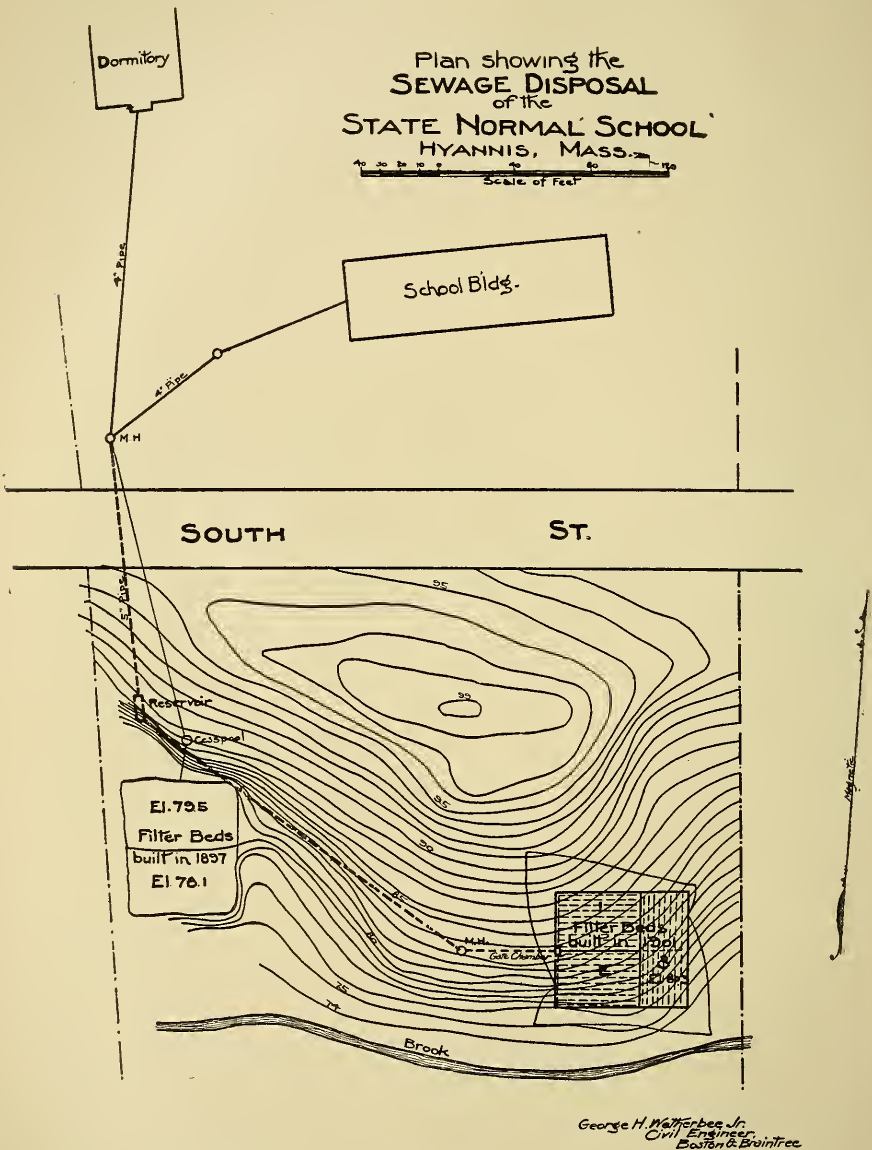
This area is divided into three beds. Beds 1 and 2 contain 1 350 sq. ft. each, while bed 3 contains 1 500 sq. ft. By means of a gate chamber the sewage is directed to the different beds through 8-in.pipes, from which at 3-ft. intervals, and at right angles, 6-in. agricultural tile extends into the beds.

These beds were first used in the autumn of 1901; in August, 1904, the pipes were relaid, and an extension of the beds is contemplated the coming year.

In the original plan a wire screen was built in the reservoir to intercept papers or other solids, and was worked mechanically through an iron cover in the top of the reservoir; this was attended to for a while but finally given up.

When the future extensions are made I hope that a septic

tank may be installed, or, better still, a filter bed, built at a lower level than, and adjacent to, the present beds, upon which



the sludge that now collects in the pipes can be frequently flushed.

No analysis of the sewage or effluent has been made.

The total cost of the system as built in 1901 was $900.

THE DISPOSAL OF SEWAGE UPON THE WATERSHEDS OF THE METROPOLITAN WATER SUPPLY.

By William W. Locke, Member of the Boston Society of Civil Engineers.

[Read before the Sanitary Section of the Society, March 7, 1906.]

The present water supply of the Metropolitan District consists of surface waters drawn from Lake Cochituate; from six artificial reservoirs and Whitehall Pond upon the watershed of the Sudbury River; and from the Wachusett Reservoir constructed upon the south branch of the Nashua River above Clinton.

The area of the Cochituate watershed is 19.84 sq. miles, lying in the towns of Wayland, Natick, Sherborn, Framingham and Ashland; that of the Sudbury watershed is 75.2 sq. miles, lying in Framingham, Southborough, Marlborough, Ashland, Hopkinton and Westborough, with small areas in Northborough, Upton and Holliston; that of the Wachusett watershed is about 118 sq. miles, lying in the towns of Clinton, Boylston, Paxton, Holden, Rutland, Princeton, Sterling, Leominster and West Boylston, with small areas also in Worcester, Hubbardston and Westminster.

The sanitary census recently completed shows the total population upon the Cochituate watershed to be 15 508, or 781.7 per sq. mile; on the Sudbury 21 131, or 281.0 per sq. mile; and on the Wachusett 5 772, or 49.0 per sq. mile. It becomes evident at once from a glance at these figures that the densest populations are upon the Cochituate and Sudbury watersheds. Fortunately the towns of largest population are all located near the divide lines so that it was not difficult to dispose of their sewage outside the watersheds. Sewerage systems have been installed in Natick, Framingham, Marlborough and Westborough; in the first two towns the sewage is pumped and in the last two it runs by gravity about two miles to intermittent sand filtration beds. The waters of Hardiman Brook, which drains an area of 2 sq. miles in the most thickly settled parts of Marlborough, with a population upon it of 10 074, and the waters of Pegan, Bacon and Macewen brooks, which drain an area of 1.09 sq. miles in Natick, with a population of 3 743, are also run upon sand filtration beds constructed and operated by the Metropolitan Water and Sewerage Board and filtered before they enter the reservoirs.

Up to the present time 1 427 premises out of a total of 2 873 upon the Cochituate watershed, with a population of 8 987, have been connected with the public sewers, leaving 6 521 people, or 328.7 per sq. mile, whose house drainage is still disposed of upon the watershed. Upon the Sudbury watershed 1 898 premises out of a total of 4 607, with a population of 10 556, have also been connected, which leaves 10 575 people, or 140.6 per sq. mile, whose house drainage is disposed of upon the watershed. In other words, 58 per cent. of the population upon the Cochituate watershed and 50 per cent. upon the Sudbury need not be considered further in the discussion of the sewerage problem. There are also about 2 850 people upon the Cochituate watershed and 3 130 upon the Sudbury whose drainage will be eliminated when all possible extensions of the present systems have been completed. Connections at the average rate of 153 premises per year have been made during the past 7 years. Still there will be a population of approximately 11 000 upon the Sudbury and Cochituate watersheds and 5 772 upon the Wachusett whose drainage must be treated by works in the vicinity of the dwellings. It is this drainage which we shall now consider.

Geologically the Cochituate watershed is mostly a great sand plain with only one large swampy area near Waushakum Pond. A large portion of the Sudbury watershed has an impervious subsoil with a mixture on top of clay, sand, gravel and stones and an outcropping of rocks in many places; but a fair filtering material can usually be found near at hand, if not actually upon the spot where needed. The Wachusett watershed is like the Sudbury in many respects except in the westerly and southwesterly portions, where sand and gravel are scarce.

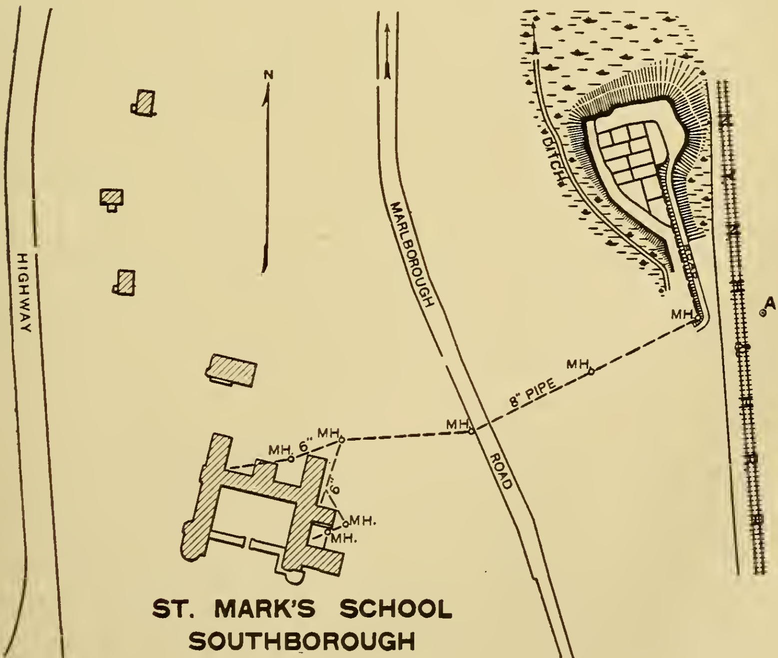
From this brief statement of the character of the soil, it will be seen that the easiest solution of the house-drainage problem is generally the construction of a cesspool, and for the protection of the Metropolitan water supply it is usually effective if the cesspools are properly located and built of adequate capacity. Unless direct supervision of their construction is taken by the inspector, however, owners are very likely to build them too small, with the result that they soon overflow. There are 983 cesspools upon the Cochituate watershed, 1 511 upon the Sudbury and 532 upon the Wachusett.

If only the health of the people upon the watersheds were to be considered, cesspools should not be built where a better

method of disposal can be found, as the turning of large quantities of putrescible organic matter into the ground, there to lie and slowly decay or to contaminate the soil or wells in the vicinity of dwellings, undoubtedly affects the health of the inhabitants. The construction of intermittent filter-beds of sand is much more hygienic and scientific, as they allow the sunlight and air and the nitrifying organisms to destroy the organic matter without polluting the soil. The only valid objections that I have ever heard raised against filter-beds are that they take up considerable space, are unsightly and require regular, intelligent attention. The last one is the most important objection, as, of course, people not scientifically trained cannot comprehend how the successful operation of the system must depend upon such little things as the regular opening and closing of gates and the raking off of a little sludge.

St. Mark's School, Southborough.

A small area was first used for filtering purposes in 1891. This was added to from time to time, and in 1901, at my suggestion, the whole area was divided into 13 small beds as shown



ST. MARK'S SCHOOL
SOUTHBOROUGH

on the cut. The total filtering area is about 14 000 sq. ft. The population is 216, of whom 135 are students. The average quantity of water used per day for 10 months is 30 000 gals., with a maximum of 40 000. During July and August the institution is closed and no sewage runs upon the beds. This makes the rate of flow about 100 000 gals. per acre per day while the beds are in commission. They are located upon a gravel knoll and were built by cutting off the top. The actual cost of construction cannot be easily determined, as the excavated material was used to build the embankment for the sewer and for various purposes about the grounds. This excavating has been continued up to the present time, resulting in the irregular area shown beyond the beds which will be utilized for additional beds during the coming summer, thus increasing the total area nearly 50 per cent.

The manager of the institution attends to the gates himself, changing the flow twice daily as he goes back and forth from the school to his home. The labor required outside of this daily supervision is 2 days per week at $1.65 per day for 5 months, or $72.60 per year.

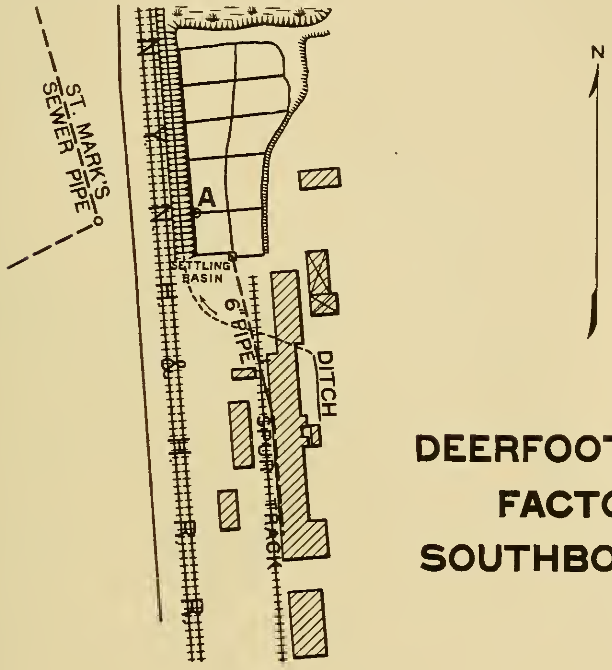
The filtering material is rather poor, being a mixture of fine and coarse sand and large stones which run in streaks. The beds are 12 ft. above the small brook and swamp which lie at the foot of the slope and 32 ft. above high-water mark in the Sudbury Reservoir, and are not underdrained.

Deerfoot Farm Beds.

One bed was built in 1897 and contained an area of 10 273 sq. ft. This was operated continuously until 1901, when, at my suggestion, it was divided into 4 beds and 6 more were added by taking gravel from the east bank and filling in the swampy area below. This increased the filtering area to 26 400 sq. ft. These beds are not underdrained and lie about 6 ft. below the St. Mark's beds and 6 ft. above the swamp.

The average number of employees during pig-killing time, which lasts for 200 days from October to April, is 60, and during the remainder of the year, when only the milk and butter departments are in operation, an average of 30 is employed. Five thousand pigs are slaughtered annually, about one third of the blood and the washings from the slaughtering, packing and sausage departments going upon the beds with the washings from the milk and butter departments, where 1 200 cans of milk are handled and 400 lb. of butter are made daily. An average

of only 25 000 gal., or 41 000 gal. per acre per day, is run upon the beds, but the character of the sewage is such that it is fortunate the quantities are no larger. Although the material is much more uniform and better adapted for filtering purposes than that on the St. Mark's beds, there is generally an unpleasant odor arising from it which the management has not been able to suppress entirely.



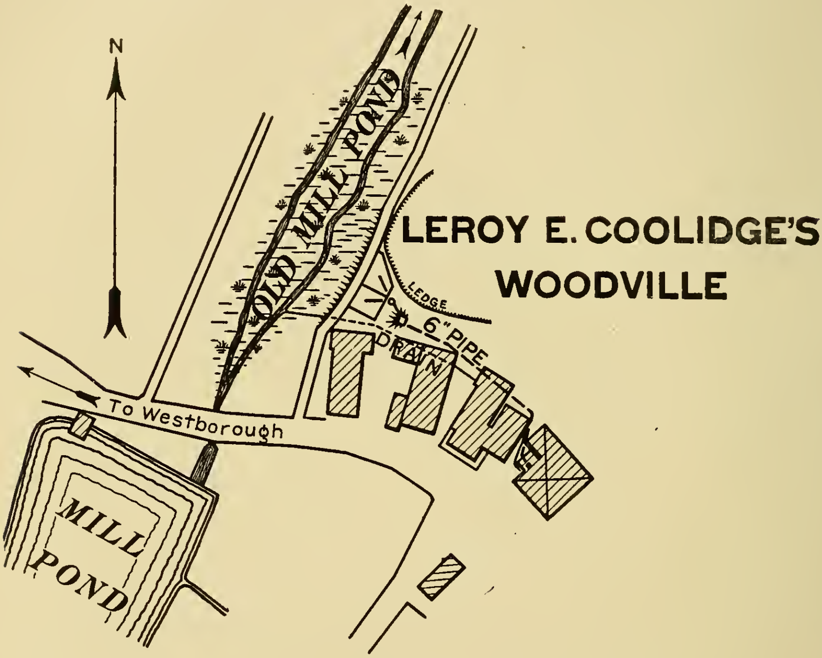
DEERFOOT FARM
FACTORY
SOUTHBOROUGH

It is not possible to give even an approximate estimate of the cost of building these beds, as the work was done by the men employed in the pork department when there was nothing else for them to do. The cost of maintenance is about $300 per year.

LEROY COOLIDGE'S.

This plant consists of a livery stable, hotel, electric light station and carriage manufactory. Formerly the drainage from the stable and hotel ran directly by a drain into Whitehall Brook. In 1903 the present system, designed by Mr. Leonard Metcalf, was built. It consists of a 6-in. pipe line, a dosing tank 10 ft. by 12 ft. by 4 ft. deep and two artificial sand filter-beds, each with an approximate area of 1 250 sq. ft. It was difficult,

because of ledge, to find a suitable area for the location of the beds. Finally a public way running between the buildings was taken and a new way built by filling out into the old mill pond with the excavated material from the site of the beds. Four-inch open-jointed tiles were then laid, upon which 3 in. of screened gravel 1 in. to 2 in. in diameter were spread; then 3 in. of gravel $\frac{3}{8}$ in. to 1 in.; then 3 in. more of coarse sand from $\frac{1}{8}$ in. to $\frac{3}{8}$ in., and upon the whole 3 ft. 3 in. of coarse sand of very good quality. This sand was found in a pit about 1 mile away and was not



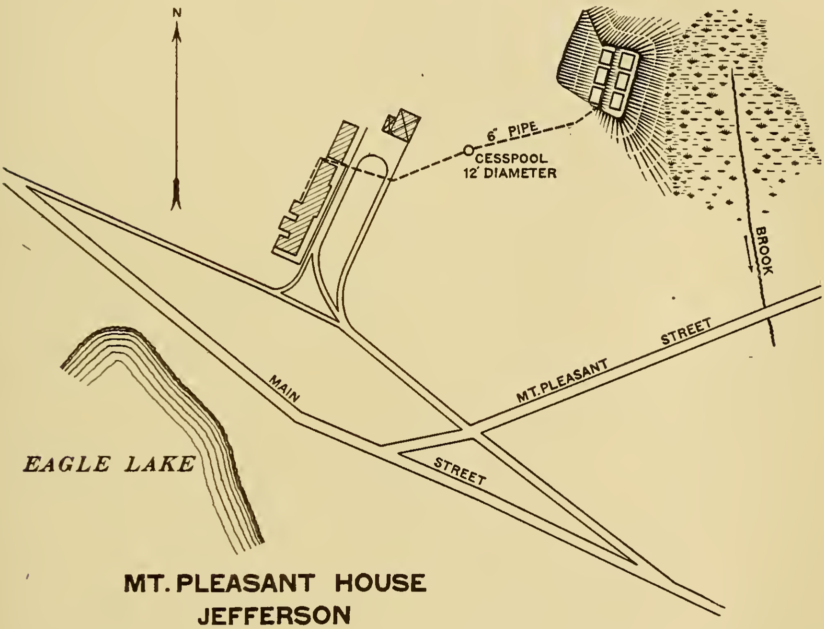
screened. The cost of the system was relatively large because of the difficulties encountered.

The average quantity of sewage from the hotel is only 700 gal. per day and this is all that goes upon the beds except for 2 or 3 months of the year when there is usually a large addition from the cellar of the livery stable. The beds are cared for by the engineer of the electric light plant. He empties the dosing tank twice a week and rakes off the sludge whenever he thinks it is necessary. At first the beds worked too freely, as inside of 15 min. after the dose was applied the sewage had disappeared from the surface and was running from the under-

drains. It came out clear and colorless but with a bad odor. As the beds gradually silted up, better results were obtained, and inside of a year the cold effluent had lost its odor.

Mt. Pleasant House, Jefferson.

This is a family hotel, having about 150 guests in summer and 20 in winter. Originally the sewage ran to a large cesspool near the main street with an overflow pipe into Eagle Lake. In 1903 6 filter beds, each about 20 ft. by 30 ft., were built by the Metropolitan Water and Sewerage Board at a total cost of

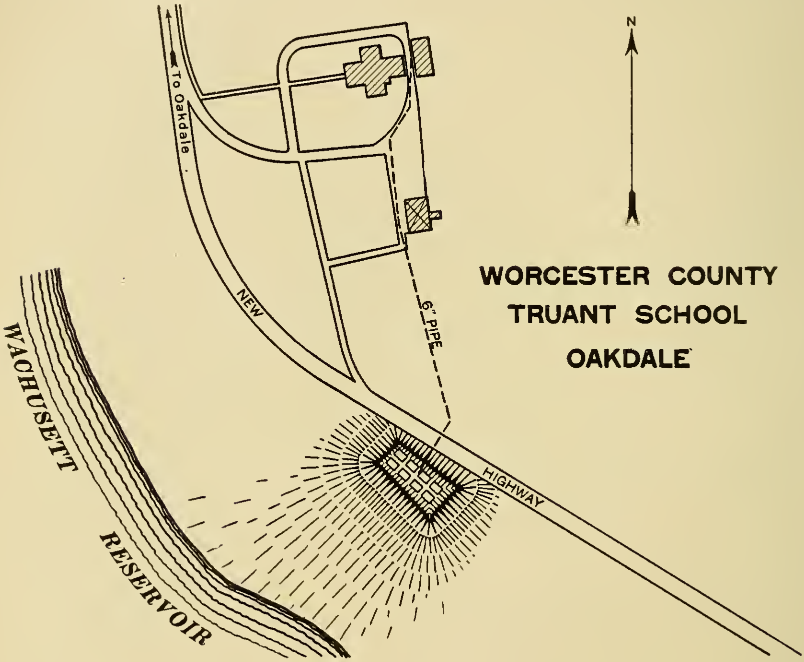


MT. PLEASANT HOUSE
JEFFERSON

$485, not including the cost of the sewer pipe. The beds are located on the hillside, about 500 ft. east of the hotel and 40 ft. below it, at the only point where filtering material could be found. Satisfactory results are obtained even though the material is not especially good for filtering purposes, being a fine sand mixed with more or less clay, and the management of the beds is in the hands of the hotel people themselves. In 1904 a large cesspool was built on the sewer line to receive the winter's flow, as the sewer froze solid at the lower end during the coldest weather. The maximum quantity of water used during the summer is 5 000 gal. per day, with a daily average for the year of 1 500 gal.

Worcester County Truant School.

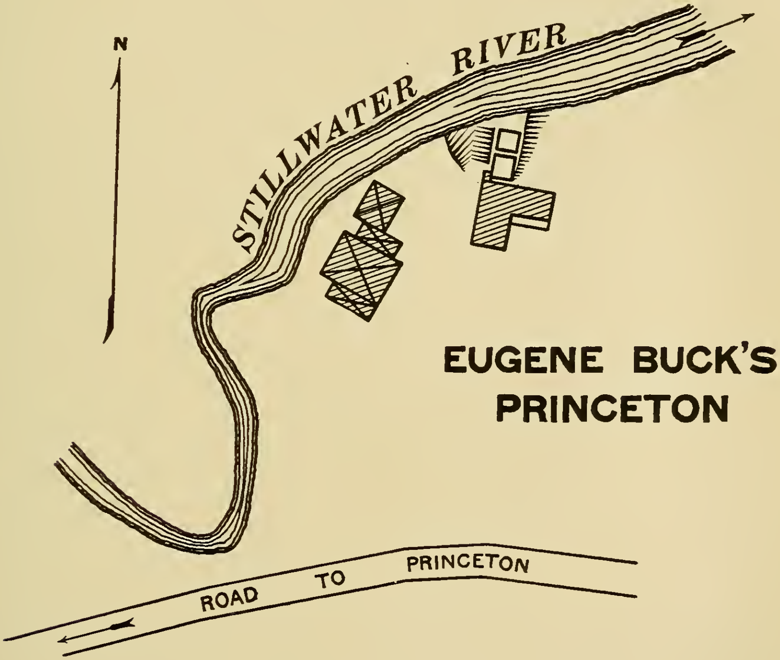
The sewage from the school ran originally to a small cesspool in the driveway, with an overflow pipe down the hill to the South Branch of the Nashua River. In 1903 the Metropolitan Water and Sewerage Board constructed 8 filter beds each 15 ft. by 20 ft. in a natural pot hole about 300 ft. from high-water mark of the Wachusett Reservoir and 50 ft. above it. The material is especially good for filtering purposes and we are operating these beds ourselves, as they were built on land owned



by the Board. They are about 35 ft. below the school and 750 ft. from it. The total cost of construction, including the sewer, was $525. The number of people in the school is 50 and the daily average sewage flow is about 1 200 gal., with a maximum of 1 800. The flow is changed from one bed to another every 10 days, at which time the depth of sewage upon the bed is 12 in. During the past year the beds have been cleaned and the sludge removed three times, at a total labor cost of $7.85. I have never noticed anything stronger than a slight musty odor arising from the beds even in May before the sludge from the whole winter's flow had been removed.

EUGENE BUCK'S.

The cut is intended to show what may be done at a farmhouse containing only six people. A cesspool was out of the question, as the material was ledge overlain with bowlders and clay. Originally the sink drainage ran upon the surface at the rear of the house and soon found its way into the river. The clay and bowlders were removed down to solid ledge, which had a dip toward the river of about 10 per cent. Coarse sand and gravel were hauled about 0.75 mile and the two beds, each



about 10 ft. by 12 ft., were built. The depth of sand close to the house is 3 ft. and at the lower edge of the second bed about 5.5 ft. A small trough conveys the sewage to the further bed. Mr. Buck attends to these beds himself, changing the flow once a week in warm weather, first raking and removing the sludge from the bed which has been resting for a week. These beds were built by the Metropolitan Water and Sewerage Board at a cost of $81.50.

The method of operation of all the systems in winter is to place stones about 6 in. in diameter at frequent intervals on the beds,

then confine the sewage flow to one bed until a covering of ice is formed which will act as a protection to the bed, keeping the sewage warm and allowing it to filter in the coldest weather. This plan worked well a year ago and two years ago, when there were many days of very cold weather.

No chemical or bacterial examinations were made of the effluents from any of these systems, as Leroy Coolidge's is the only one in which the beds are underdrained.

TEN YEARS' EXPERIENCE WITH BROAD IRRIGATION AT VASSAR COLLEGE.

By Ellen H. Richards and Charles W. Moulton.

[Read before the Sanitary Section of the Boston Society of Civil Engineers, March 7, 1906.]

An editorial in the *Engineering Record* of January 27, 1906, on recent views of the sewage problem, states that "The old idea that sewage farming is the best method of disposal was exploded long ago, and the sewage farms still in service are not kept in operation because they afford the most economical treatment, as a rule."

Soon after its promulgation, the farm disposal idea suffered a defeat from which it has not recovered. It came before the conditions of success were understood. Clayey soils, easily water logged, are, as we now know, unfavorable to the bacterial activity required. In the far-away decades of the sixties and seventies, even down to the eighties, there was no recognition of the fact that nearly all the value of one batch of sewage applied to land *may* be lost as gaseous nitrogen by the application of the next batch, and that a considerable portion always is lost. Hence the disappointment in the meagerness of results.

There are cases when the question "Will it pay?" has to be answered, "Not in money, but in sanitary service to mankind."

Such a case arose ten years ago when Vassar College, situated about two miles from the east bank of the Hudson River, and south of the city of Poughkeepsie, was enjoined from turning the sewage of 1 000 persons into Kaspar Kill Creek, a small tributary to the river. It was proposed to build a sewer some six miles in length to the Hudson at an unknown cost (estimated at $50 000). But, in view of the possibility that in 20 or 30 years the enlightened state authorities would pro-

Looking Southeast from Outlet of Irrigation Pipe, showing Furrows for Distribution. Line of Trees in Front of Barn Marks Gully bounding Field.

Diagonal View across Filter Bed toward Corner where Sewage Empties. The Sewage sinks in without covering the whole Bed. Undisturbed Snow in Foreground. Dike in Distance running in Direction of Tree.

hibit the turning of untreated sewage into rivers, the trustees were willing to have an experiment tried involving much less expense.

An ideal field with most suitable material offered itself for irrigation and was laid out under the direction of the lamented Albert F. Noyes and of Allen Hazen.

No one of the advisers quite dared to risk broad irrigation by itself, and so the two filter beds were constructed. The pipe line is 3 000 ft. long to the filter beds and extends 500 or 600 ft. farther to the irrigation outlets. The beds cover 1 acre; the filling is 0.3 to 0.4 mm. effective size. The ground water level being 15 ft. below, no underdraining is necessary. The line carries easily 10 000 or more gallons per hour. The original cost, including the engineering reports on abandoned projects, was $7 500.00.

The description of the installation will be found in the *Engineering Record* for June 27, 1896.

The filter beds have not been refilled in the ten years. The surface is plowed and harrowed over every four or six months. If the grade from the pipe is kept up (not allowed to sink so that water stands) and paper stirred up occasionally to prevent clogging, the sewage received from 8 A.M. to 2 P.M. (the usual hours of pumping) disappears before the next morning. The two *beds* are used alternately whenever the *field* is out of commission more than four weeks at a time. This use occurs between planting and harvesting, and whenever an intense cold is in danger of freezing the pipes leading to the field. These are laid only 4 to 5 ft. below the surface and on a raised dike. They have not broken and have not needed repair in the ten years.

When college opens in September, the silo corn is gathered, furrows are plowed out radially on each side of the dike, extending 40 to 50 rods, so that there is a grade of about 1 in. in 30 ft. At the end of 6 hours' pumping the water has reached a distance of 300 ft. in these furrows, the soil being porous enough to absorb about all the liquid within 6 hrs. of stopping the pumps.

Since fresh sewage gives no offense, it is only when the grade has been allowed to wash out and a puddle to form that cause for complaint arises.

The crop raised is silo corn, which grows to a height of 16 ft. The yield of the land has steadily increased and is now 50 tons ensilage per acre — double what it was at first. For 2 years there has been no good corn in the region except on this

farm. About 10 acres have been irrigated with something like 100 000 gallons per day. Approximately 20 acres are available, at little expense, if branch pipes are laid.

To rake the field and beds requires two men and a team, 8 days for each bed, twice a year.

The inspector should visit the outlet every second day to see if anything is going wrong.

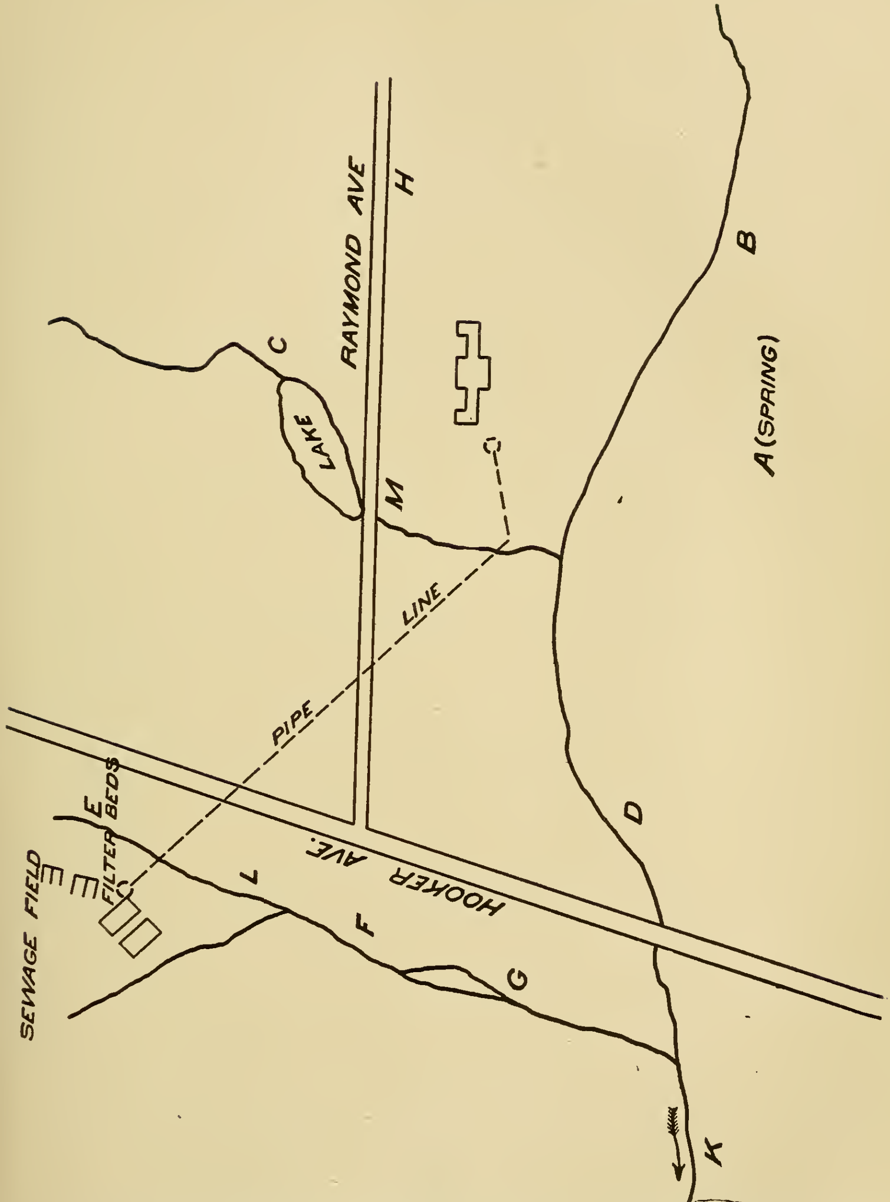
The great element of success is the character of the soil — a sandy loam. The lime, iron and humus content make a favorable combination for utilizing the values of the sewage. Sand is a good filter medium, but lime and humus will purify more efficiently.

Analysis of the Soil.

Sieve Mesh.	Per Cent. passing through.	Per Cent. Humic Acid.	Color Am. Standard.	Parts per Million.	
				Loss on Ignition.	Oxygen Consumed.
30	10.0	1.51	18.5	55	69.7
40	12.1	1.03	18.5	60	70.9
60	28.8	1.60	13.9	53	—
80	12.6	1.78	12.5	—	59.8
100	17.7	—	11.7	48	—
120	8.5	—	13.5	—	—
170	16.6	2.66	25.0	84	116.6

Doubtless much of the nitrogen is lost by denitrification, but no great increase in that of the deeper ground waters has taken place, as shown in the analyses. Samples have been taken at least twice a year by Professor Moulton and a close watch kept of the general conditions. The table gives selected results covering the ten years, together with those of surrounding localities for comparison.

This is a valuable record of the possibility of sewage utilization without offense, and of the right principle in taking care of the wastes of an establishment by itself, instead of fouling a stream to become a menace to the health of others, and an expense to helpless dwellers farther down. It is thus in the line of modern economic and sociological investigation — a line which must be followed up if the land is to remain safely habitable.



A is a spring on the slope of Sunset Hill, unpolluted water. B is from the creek as it enters the college grounds on the North. D is the same creek just before it leaves the grounds on the South below the gas works. It was, at this point, very offensive at the beginning of the investigation. C is a small stream coming into the grounds from the West and feeding the boating lake. H is the well from which the college supply has been pumped. E is taken above the sewage field and beds from a small stream parallel to C, flowing through farming country. L is the stream just below the beds. F is the stream after receiving a tributary, draining a large stock barn and the sewage field. K is the creek after the junction of this drainage stream.

Analyses.

PARTS PER MILLION.

Point of Collection.	Date.	Total Solids.	Alb. Amm.	Free Amm.	Nitrites.	Nitrates.	Hardness.	Chlorine.
A Spring	May 28, 1896	73.0	.014	.000	.000	.050	44.0	1.1
	September 30, 1895	190.0	.232	.014	.007	.200	94.3	9.8
B	May 5, 1896	135.0	.058	.006	.000	.070	81.0	3.0
	October 13, 1905	160.0	.264	.024	.001	.300	73.0	6.6
	September 30, 1895	214.0	.090	.000	.007	.800	120.6	7.1
	May 5, 1896	224.5	.126	.034	.014	1.560	152.0	8.1
C	March 5, 1902	186.0	.124	.092	.014	1.900	103.7	7.7
	October 13, 1905	247.0	.140	.010	.006	.750	153.0	9.2
D	September 30, 1898	193.0	.162	.120	.025	.750	103.0	7.2
	October 10, 1895	157.0	.012	.002	.000	2.600	90.0	3.6
H	May 5, 1896	136.0	.006	.000	.003	1.050	87.0	3.6
Water	November 12, 1897	153.0	.006	.000	.000	1.203	84.0	3.6
Supply	September 30, 1898	133.0	.000	.000	.000	1.100	74.0	4.0
of	November 6, 1900	140.0	.001	.000	.000	1.600	88.0	5.1
Vassar	December 10, 1902	161.0	.006	.000	.000	1.500	104.0	6.1
College	October 29, 1903	—	.000	.000	.000	2.000	88.0	4.4
	March 16, 1905	170.0	.008	.004	.001	1.000	105.0	5.6
	October 13, 1905	173.0	.004	.000	.000	1.250	107.5	5.24

PARTS PER MILLION.

Point of Collection.	Date.	Am. Standard Color.	Total Solids.	Loss on Ignition.	Total Alb. Amm.	In Sol. Alb. Amm.	Free Amm.	Nitrites.	Nitrates.	Oxygen Consumed.	Hardness.	Chlorine.
E	September 9, 1895	0.03	99.0	—	.020	.010	.000	.002	1.220	1.131	56.	3.4
	September 30, 1895	0.10	110.0	19.0	.038	.020	.000	.003	1.000	1.248	59.	3.4
	October 14, 1895	0.45	239.5	75.5	.396	.300	.452	.043	1.600	7.566	122.	10.0
	October 28, 1895	1.30	187.5	42.5	.288	.204	.032	.009	0.150	14.820	115.	7.6
	April 16, 1896	0.23	150.0	33.5	.150	.130	.060	.005	0.330	3.388	109.	3.7
	May 28, 1896	0.30	158.0	42.5	.172	.148	.016	.012	0.350	2.120	90.	3.4
	November 19, 1896	0.12	180.0	30.0	.146	.118	.022	.011	0.300	2.847	139.	4.2
	November 12, 1897	0.17	209.7	35.0	.100	.088	.056	.007	0.700	—	94.	5.6
	September 30, 1898	0.18	196.0	34.0	.066	—	.022	.012	0.580	—	126.	4.5
	March 5, 1902	—	175.0	35.0	.116	—	.090	.015	1.900	—	104.5	3.7
	October 29, 1903	—	213.0	—	.048	—	.030	.030	1.900	—	150.0	4.0
	December 3, 1904	—	—	—	.090	—	.040	.005	0.500	—	—	3.4
	October 13, 1905	—	190.	38.	.262	—	.084	.011	0.350	—	128.0	6.0
	December 26, 1905	0.03	207.	29.	.042	—	.038	.001	1.700	—	170.	3.6
L	October 28, 1895	0.70	145.5	30.5	.148	.112	.004	.003	0.030	10.920	94.	5.0
	November 11, 1895	0.20	135.0	22.5	.080	.074	.008	.001	0.280	2.379	86.	4.4
	April 16, 1896	0.25	144.5	23.5	.140	.114	.024	.004	0.330	3.080	109.	3.2
	May 28, 1896	0.30	131.5	21.0	.142	.096	.042	.006	0.400	2.574	103.	4.2
	September 16, 1896	0.22	156.0	31.0	.116	.090	.090	.020	0.400	2.106	97.	5.8
	November 19, 1896	0.12	175.0	43.0	.094	.078	.018	.002	0.600	2.301	116.	8.5
	November 12, 1897	0.10	205.0	45.0	.094	.064	.026	.005	0.850	—	101.	10.9
	September 30, 1898	0.18	217.0	64.0	.046	—	.012	.008	1.900	—	127.	13.6
	November 6, 1900	0.20	310.0	72.0	.046	—	.004	.010	6.500	—	161.4	25.1
	March 5, 1902	—	198.0	33.0	.112	—	.114	.016	2.250	—	121.1	9.96
	October 29, 1903	0.17	203.0	—	.032	—	.014	.020	2.500	—	139.1	6.8
	December 3, 1904	—	—	—	.122	—	.038	.006	2.500	—	—	11.2
	October 13, 1905	—	206.0	49.0	.180	—	.044	.009	1.000	—	133.0	9.0
	December 26, 1905	0.10	219.0	37.0	.046	—	.052	.002	2.300	—	175.4	6.7

PARTS PER MILLION.

Point of Collection.	Date.	Solids.	Alb. Amm.	Free Amm.	Nitrites.	Nitrates.	Chlorine.
F	September 30, 1895	142.0	.122	.094	.010	.300	5.0
	October 14, 1895	198.0	.276	.192	.033	1.000	8.0
	December 17, 1895	123.0	.082	.090	.006	.530	2.4
	April 16, 1896	150.0	.122	.014	.004	.500	4.0
	May 28, 1896	141.5	.112	.048	.011	.400	6.8
	September 16, 1896	153.0	.940	.148	.030	.400	6.2
	November 21, 1896	177.0	.094	.030	.002	.800	10.6
	April 14, 1897	—	.072	.014	.006	.400	6.0
	November 12, 1897	210.0	.102	.042	.005	.850	11.1
	September 30, 1898	235.0	.182	.018	.010	2.000	15.6
	December 3, 1904	—	.064	.060	.007	2.650	13.8
	October 13, 1905	210.0	.216	.034	.008	1.000	8.2
	December 26, 1905	231.0	.042	.092	.003	8.000	11.0
K	October 14, 1895	204.0	.496	1.008	.050	.300	10.4
	December 17, 1895	215.5	.228	.696	.020	.800	6.9
	April 16, 1896	143.5	.202	.088	.007	7.200	4.5
	May 28, 1896	167.5	.244	.018	.040	.400	5.8
	September 16, 1896	192.0	.246	.072	.080	.400	7.5
	November 21, 1896	185.0	.268	.264	.014	.500	7.2
	April 14, 1897	—	.244	.078	.012	1.000	5.1
	November 12, 1897	87.0	.312	.144	.007	.550	7.0
	September 30, 1898	190.0	.148	.116	.040	.700	6.2
	December 3, 1904	—	.128	.256	.007	1.400	6.4
	October 13, 1905	176.0	.204	.164	.009	.400	11.10
	December 26, 1905	168.0	.120	.370	.006	1.800	6.4

SOME FOUNDATIONS FOR BUILDINGS IN CLEVELAND.

By Gen. J. A. Smith, Honorary Member of the Civil Engineers' Club of Cleveland.

[Presented to the Club Feb. 13, 1906, with discussion Feb. 13 and 27.]

I do not want to take exceptions to the announcement as given, but it may perhaps be as well in the start to know that I am not going to have any paper. I have simply a few points that have been jotted down as memoranda that I may bring them in in their proper sequence, and they will not be read. I hope to make the points sufficiently clear as we proceed.

Cleveland is a city that is fortunate in having somewhat upon which to rest. That is true not only of its people, of its homes, but of its sand. This discussion will be limited to the small section of Cleveland on this side of the river as far as Erie Street and including that which we ordinarily term the business part of the city. There is perhaps no better way in which we can tell what to do in the future than by what has been successfully done in the past; and while we do not always want to go along through the world looking backward in order that we may see what is behind, the wise man will occasionally glance back to get the information which he needs for his forward road. Cleveland, within a comparatively few years, has grown to be a city in which large buildings have arisen. I propose to take you along with me to a few of them.

Among the earliest, not the very earliest, was the building known as the Arcade, reaching through from Euclid Avenue to Superior Street. Its foundations are upon the sand, with a difference of level between the foundations at the two streets of about 11 ft. 3 in., and that entire difference of level, if I remember correctly, is within a distance of about 70 ft. The foundations of that building were put in upon a very fine sand and in the water, protected, as I understand, while being constructed, by caissons of boiler plate, which, however, have been omitted in many buildings similarly constructed since. The weights upon those foundations (in the water) vary between the limits of 3.25 and 4.25 tons per superficial foot. The observations of the architects and others have not detected any material settlement, in fact, practically none at all, and *none which is unequal* throughout the building.

Within little more than a year a new power plant has been erected for that building, and I am informed that portions of that plant, including its engines, rest upon foundations deep in the water, so as to look as though they were afloat, and they carry 3.5 tons per superficial foot, *absolutely without settlement to detect.*

If we pass along further east to the Hollenden Hotel, upon the street between the rear of the Hollenden and the rear of the Garfield Building, we find that a recent addition has been made to that hotel. I have had occasion from time to time to observe the excavation in the sand and the putting in of ordinary foundations upon ordinary footings. This part [illustrating] is intended to represent the rear of that addition that has been built ten stories high, and that against which it was built is eight stories high. What is singular and noticeable about this is that when the top of the wall of the old part was reached — in which I myself had rooms some fifteen years ago, so that I know it has been in position at least so long, and has doubtless reached all the settlement it ever will, — this second wall was carried over on the top of the wall of the old part, whereas up to that height the two walls are separately built. I have been watching for a catastrophe. I have been waiting to see whether cracks would appear from the top of the old wall to the corner of these windows [illustrating] and to see whether they would extend anywhere through these walls, as they surely would if the new part had settled. It may be that my eyesight is not good, but from the narrow width of the street and on pretty nearly the same level, I have failed to discover any indications of a break because of the settlement of the lower part away from that which would be held above by the old wall.

If we come along to the Citizens Building at our next door, we find a structure 183 ft. high. Its foundations are on sand about 2 ft. above the water. The plan was to distribute the weight as nearly uniformly as possible, and the weights there have been small compared to some of these other buildings. They are calculated at the rate of 2 tons per superficial foot. I have had an office in that building something like two years and a half and have rarely gone through it without glancing at the walls to see if a crack could be found. I have not been greeted thus far with any such sight. The architects state that there has been no settlement in the building, but where the sand had been disturbed, broken loose under the sidewalk, portions of the sidewalk had noticeably settled.

We are in a building approximately of the same height, and just across the alley is the Rose Building. They stand as mute testimonials to the solidity of their foundations, and if we walk back down the avenue we pass some more.

First, the Guardian Trust, recently built, and then we come to the Williamson Building. That building was erected at a time when the pumps had to be kept going to clear the water so that the men could work; a permit was obtained from the Director of Public Works to enable them to work on Sunday to prevent their excavations being filled with water. Its foundations rest upon the fine sand in water.

It may be noted that on the site where the present Post-office Building is being erected the old postoffice stood for many years, and adjacent to it, the Case Building. I do not know what may have happened to them, but if anything very serious happened on account of instability it has not generally gotten out, so as to be known.

Near that place is the Society for Savings, one of the heaviest buildings in the city. Its foundations, to be sure, are comparatively shallow, compared to some of the later buildings, but it stands there and is likely to remain until some of us shall have passed away.

Perhaps the most remarkable foundations in recent constructions are those of the new Rockefeller Building. A few days ago I took pains to put in an entire half day in examining that building and went with the architect from the top to the bottom of it, making a complete examination. I have made a sketch here, which shows the principle to illustrate, but, of course, does not show in exact scale.

The sidewalk grade has been taken at 82.24 above the mean lake level, and the footings of the front part are at an elevation of 66.24 or 16 ft. below that datum; 5 ft. 10 in. above these footings is the floor of the front part in which are the safety vaults. In the rear of that part and down an additional distance of more than 15 ft., a retaining wall has been put in here [illustrating]. In rear of this wall is the "Machinery Hall," of which the floor is more than 25 ft. below datum of sidewalk.

The room for boilers and storage of coal is still lower, being about 27 ft. below the datum, and the footings of walls are 5 ft. 10 in. below the respective floors. These lower footings all rest upon the fine sand in the water and the lowest are but two feet above the underlying stratum improperly designated as "clay."

From the footings on the Superior Street front to the lowest footings under other parts of the building, the difference of level is about 17 ft., and the building stands in the water like a vessel in the lake, with a draught of at least 10 ft.

Between the footings of the walls and piers a layer of concrete 8 in. thick was placed on the sand; this concrete was covered with a water-proofing and upon that was placed another layer of concrete 6 in. thick. Between this concrete and the floors of machinery hall and boiler room, the space is filled with sand. Notwithstanding the depth of water around the lower rooms, a 4-in. well or boring, recently made through the floor of Machinery Hall to a depth of 40 ft. below the clay surface, was without any inflow of water. The architects called it "a dry hole." This seems to indicate that the material immediately overlying the clay is neither a "quicksand" nor other porous material. In fact, this material when moist may be squeezed into a lump in the hand, and the lump when dried becomes somewhat hardened, though easily crumbled.

Inquiry regarding the settling of the building elicited information that the settlement had been about 2 in., and had been so nearly uniform that no difference had been detected. As there is a large difference in the thickness of the sand underlying different parts of the foundation, the conclusion seems inevitable that the uniform load of 3 tons per superficial foot on the footings had caused no perceptible compression of the sand, and that the settlement must therefore have been due to displacement or compression of the underlying material.

Of course, such a conclusion assumes the accuracy of the statement of fact, which has been repeated as understood and noted when given by the architect of the building.

All of you know of many more buildings than I have mentioned, as being founded on the compact sandy material underlying the surface of the larger part of this city, and many of them contain busy machinery which keeps up a constant throbbing and jarring which tax the foundations far beyond what any steady pressure could do.

Some of the experience which has been gained by observing the results of such practical application of sound judgment in the past, has been codified and arranged in this book which we all know as the New Building Code. From this I propose to read a single paragraph relating to foundations:

"SECT. 2. Foundation Soil [page 47]:

"Foundation walls are to be laid on solid natural earth,

or a level surface of rock, or concrete. Where solid earth or rock is not obtainable the foundation walls are to be supported on caissons filled with concrete or on piles," etc. In other words, this Building Code indicates that where we have a solid soil upon which to build, that should be utilized without going to the needless expense of placing it upon foundations which are only justified when we have nothing better upon which to build.

Some three years ago, 26 borings were made on the lake front on the site where it was proposed to erect a new Court House. Those borings were all made down and into the clay to a depth of from 50 to more than 60 ft. below the surface of the ground, and as a general rule, 25 ft. or more into the underlying clay. The material over that clay was reported to be generally of a sand, becoming finer and cleaner with additional depth, to the top of the clay, and later experiments have found that the water stood over that clay at a level of about 49 ft. and 8 in. above the lake.

Let me invite your attention to the fact that those borings were made from the top of the surface to the bottom of the clay, removing the auger at short intervals of 2 or 3 ft. to obtain the samples of material which were preserved. Those holes were made without casings and each time that the auger was removed and reintroduced into the hole it went down again to the bottom of the previous boring. In that same line a similar result has recently been obtained by the Cleveland Engineering Company down here in the little alley we know better as Hickox Street. There, in the several borings that were made, the engineers tell me that each time the auger was replaced it went entirely to the bottom of the hole from which it had been raised, and although seven or more feet of the fine sand over clay is in the water, even then the material did not fall into the hole.

There has been a popular idea that that sand overlying the clay was a quicksand. It is quite possible that may be true in some little pockets, but it certainly *is not true in the place in Hickox Alley*, or in several other places in which I have seen the boring records; nor is it true down near the foot of Ontario Street between Summit and Lake streets. There is no true quicksand there. It is simply a very fine gray sand, doubtless mixed with some other very fine material.

As an addition to the 26 borings some tests were made last spring. First, a well 6 ft. in diameter was sunk in a casing of boiler plate iron. The bottom of that casing now stands near the bottom of the fine sand which apparently carries the weight

of the casing which would slide down of itself if not supported, and the pressure from the outside has not raised the surface inside the cylinder at all, as recent measurements have shown.

The well was first sunk to the water level, which was 49 ft. 8 in. above the lake level. From the bottom of the well a long pile was driven to a penetration of 37 ft. and 4 in. Material around the pile was then removed to a depth of 5 ft. below the surface of the clay, still leaving a depth of 27 ft. 8 in. of penetration. The diameter of the pile at the point was 8 in. and at the top of the part in the clay it was about 1 ft.

With a view to testing the bearing capacity of the pile, it was loaded with pig iron to the amount of perhaps 200 or 300 lb. more than 14 tons. Under the weight the pile settled 3 in. in two weeks, according to information furnished by the county surveyor's office, and the observations, which were not very regularly taken, indicated an accelerated motion so that in the last two days of the two weeks the settlement was 1.2 in. The result, therefore, only showed that such a pile penetrating more than 27 ft. in the substratum of clay, with its point more than 57 ft. below the street, and more than 60 ft. below surface of the ground, could not be depended upon to hold nearly as great a weight as 14 tons.

From the bottom of the same well a hole was then bored to a depth of 70 ft. below street grade, which brought the bottom of boring to the lake level. The substratum called clay was found to be substantially uniform and homogeneous throughout. From other sources we well know that this substratum is practically the same throughout the very large area underlying nearly all and perhaps all of the city of Cleveland.

At the Kirtland Street pumping station which is on a lower level than this plateau, there is no overlying stratum of sand, and as the clay stratum can carry but small amounts without settlement, piles were driven to sustain the exterior walls, engines, and chimney. Under the walls, chimney, and engines large piles were driven to a penetration of 35 ft. from the bottom of an excavation such that the column of earth above the top of pile caps on the outside is 27 ft. The piles were not less than 8 in. in diameter at the points and not less than 14 in. in diameter at the top. Of course, some of the piles were larger than the dimensions given.

Upon the piles driven to support outer walls a load of 15 tons each was placed. Under the chimney and engines the load was 12 tons per pile. As an experiment that construction has

not determined the load which such piles will safely carry in that material, because they have all settled. Let it be remarked that the material in which the piles were driven is in all essential respects the same as that which underlies the sand at the Court House site, it being a continuation of the same original formation.

The engineer in charge of this work states that accurate measurements have not been made of the settlement under the walls, but it is quite unequal and is estimated at from 1 to 2 in. Under the chimney the settlement has also been unequal, and has ranged from about five eighths of an inch to double that amount.

Of course, we understand that the amount of settlement is not large, but neither were the weights, though the amounts were too large and too unequal to be hazarded under any very important building, as the cracks in the pumping station amply demonstrate.

No such amounts of settlement as these can be found in the heaviest buildings of Cleveland, where they have foundations spread upon the hard sand which has been incrusted in the ages which have gone.

Now we come to a little practical application of some of these points. If a pile on the site of the Court House, driven 27 ft. and 8 in. in the clay, with its point more than 60 ft. below the surface of the ground, lamentably fails to hold a little more than 14 tons, how big must a pile be to hold anything? This is in all seriousness, because we have a similar problem before us. With this experiment, and the fact that large piles at the pumping station driven 35 ft. in the clay with their points more than 60 ft. below the top of the ground failed to sustain 12 tons each without settlement, by what process of logic can we expect that a metal pile 14 in. in diameter and driven but 20 ft. will hold 25 tons without settlement?

But this is exactly what the specifications require the shorter piles to do. In the specifications for building the Court House the method described to determine the length that piles must be driven to hold the loads that are to be placed on them is simply this: The contractor is to drive 12 piles each 20 ft. long, in groups of four in different parts of the building site. Each of the groups is to be loaded with a weight of 100 tons, and the specifications require that this load must produce no settlement during one week.

In some places we use wooden piles where they will be constantly saturated so as to be beyond a question of decay, but if

they are to be used under a building where decay is possible, it becomes necessary to introduce a material which is not subject to that element; therefore the introduction of what are commonly known as concrete piles. These are ordinarily a hollow form, usually of some wrought metal, filled with concrete. Should the metal decay, the concrete would still stand and hold its load.

Regarding the size and shape of the piles in this case, the specifications permit either a cylindrical form with a diameter of 14 in., or a tapering form with ends 10 and 18 in. in diameter respectively. When an option is given between two methods one may be sure of the adoption of that which costs the least, which would apparently be the one with the cylindrical form.

Again referring to the requirement for determining the lengths of piles to sustain the loads which they must carry, suppose that the piles should refuse to obey instructions, and should settle under their load of 25 tons each; by what reliable formula shall we deduce the lengths to carry other loads?

I have tried without success to repress the question, "What are we going to do should the piles settle contrary to instructions?" And how can we reasonably expect any other result when our experimental pile driven to a much greater depth failed to sustain a load which was less than three fifths as much? How are we to justify ourselves in assuming that these piles, but 20 ft. long, whether driven the whole length or not, will hold 25 tons each without settlement, when large piles driven 35 ft. in the same general formation failed to hold without settlement a load less than one half as great?

I have recently looked over some tables giving certain coefficients of friction. Unfortunately, no coefficients are given for friction of metal in the earth, or for wood in the earth. But in general the coefficients for metals are less than for wood, and you will find that the average coefficient of friction of metals upon each other or upon wood is considerably less than the corresponding coefficients for wood upon wood. This is not without exception, but is true in general. It seems logical to conclude that the surface friction of a metal pile driven in the earth would be less than that of the wooden pile which has a less uniform surface.

Another principle comes in here. Water under pressure due to its own weight or other conditions will follow the division between two uniform surfaces to a wonderful distance. I have known serious injury to a dam of earth because of the passage

of wagons over it during construction, so that there was a hard and practically uniform surface between the earth compressed by the wagon wheel and the superincumbent material.

The material underlying the sand at the Court House site is by no means impermeable to water, and it is ordinarily covered with water-bearing strata. Under such conditions it is a well ascertained fact that there is a greater liability to settle with the lapse of time because of the admission of water between the pile and the surrounding earth. It seems probable that this effect would be greater in the case of a pile with metal surface than with a surface of wood which would be less smooth and uniform.

The pile maintains its load through two agencies. Primarily we have the force which is required to displace the material in which the pile is driven, and to that is added the friction upon its surface. The greater the depth to which the pile is driven, the greater the force required to displace the material from under its point, and to force it laterally by the tapering form. While the lower end of a pile is generally smaller than the upper end, the greater resistance of material around the lower part is such that for the purpose of discussion we may assume that of two piles in the same material at different depths, the respective weights which they would safely carry would bear a direct relation to their lengths of penetration; this is under the condition that the upper portions have the same dimensions and tapering form.

At the Kirtland Street pumping station, where piles were driven in groups, the very common experience was had, that when a few of the piles had been driven as nearly together as practicable, the displacement of the material could not be adjusted by compression, so that in giving way along lines of least resistance the upheaval brought with it the displacement of piles previously driven. The same force which has lifted the ground surrounding the piles, has necessarily disturbed the conditions of rest and stability which had required ages to obtain, so that it can no longer bear the same weight as before without settlement. Sand which is practically incompressible after long ages of rest will again settle to a degree which, when undisturbed, could not possibly obtain.

In placing the load, therefore, we cannot depend upon the material around and between the piles to carry its share until after considerable settlement.

In the foundation of the Court House the estimate of cost is based upon the supposition that piles 25 ft. long are to be

driven 24 ft. Should additional lengths be required they are to be paid for at the same rate per foot. Let us make a proportion, and assume that the bearing capacities of the piles at the Court House and at the pumping station are proportionate to their lengths. The material designated as "clay" at the two places is of the same formation.

We shall have: As the lengths of the respective penetrations are to each other so is the weight which caused settlement at pumping station to that which will cause settlement at Court House site. Or, 35 : 24 :: 12 : 8.2 +.

But the pile driven 35 ft. failed to hold 12 tons without settlement, and no prudent engineer would assume that it could be safely loaded more than 10 tons, and, in fact, that would be too much. For sake of discussion let us assume that the long piles were to sustain loads of 10 tons each. We then have the proportion, 35 : 24 :: 10 : 6.8 +. This is less than one third of the average load which the piles must sustain if there is to be no settlement.

Let me invite attention to two groups of piles as arranged for outer and inner walls. Under the outer walls we have a large number of groups of 17 piles each; from the middle of one group to that of the next is a length of 11 ft. and 6 in., and the concrete footing to rest on the piles is 10 ft. wide. The footing therefore has a superficial area of 115 ft. The building code of Cleveland permits of loading "dry, hard clay or fine sand, compact and well cemented," with 4 tons to the square foot, and even permits the loading of the material "commonly called quicksand," when properly drained and undisturbed, with 3 tons per foot. A footing of 115 sq. ft., even under conditions not the best to be found, might be safely loaded to carry 345 tons, and if an equal weight be placed on the 17 piles which form the group, each must carry nearly 20.3 tons. This is three times as much as we have any reason to assume that the piles can carry without settlement.

Regarding the weights which the undisturbed sand can sustain with spread foundations, the amounts are so ample and well established by long experience as to be beyond the range of doubt save under conditions rarely found in Cleveland, and not at all in the area under discussion.

If the same area of footing was only loaded 2 tons per foot, it would carry as much as the 17 piles loaded to nearly 14 tons apiece. The experimental pile, 28 ft. 8 in. in the clay, notably failed to carry its load of a little more than 14 tons. By what

logic can we expect the shorter piles to hold as much without settlement?

Under most of the inner walls we have an arrangement of piles shown by the second sketch where the piles are staggered in two rows. The footings are 5.5 ft. wide and in a length of 15 ft. there are 10 piles. The area of footing for the 10 piles is therefore 87.5 ft. The same area of footing on the hard sand would readily carry 3 tons per foot if necessary. To carry the same weight as the footings alone would carry on the sand would require a weight of 26.25 tons per pile. At 2 tons per foot the footings on the sand would carry as much as the piles when loaded to 17.5 tons per pile.

When experience has shown so conclusively that the footings over these piles, if placed directly on the sand, would sustain without settlement a much greater weight than when on the piles, is it not folly to incur the expense of piling in view of the probable result?

One of the arguments which has been urged to favor the plan of a pile foundation for the Court House has been the alleged danger of a landslide which might carry the building, site and all, to some point nearer the lake. To substantiate this claim, which I have considered a "bug-a-boo" of an idea, certain unstable conditions remote from this site have been cited and enlarged upon. The most notable of these was the unfortunate experience of the Pennsylvania Railroad Company, in constructing a freight station on the high level close to the bank at Davenport Street.

I obtained the engineer's report of the sliding of the bank at that place, and of the methods employed to prevent further trouble so that rebuilding might proceed. These are the essential facts: At that place there are unmistakable evidences of several successive slides. It seems hardly probable that the one farthest from the bank would have occurred after it had been protected by other slides of earlier date on its front. It matters little in what order the slides have taken place, for resulting conditions are known. By successive slides the bank, which had doubtless originally been a steep bluff overlooking the lake, had been arranged in a series of terraces in which the corresponding strata of earth and sand could be clearly traced. On lines perpendicular to the bank, these strata were horizontal, and the successive parts formed a stairway from the lake to the high level above.

Between each two of these sections a deep crevasse was

originally formed, and these have gradually filled with silt and mud which permits the water to percolate and produce a constant outward pressure.

In building the station the outer wall had its footings on the upper portion which had previously broken away, and the other parallel wall was on the more solid ground of the high level. A large amount of sand was then placed on the terrace, to level the surface, and to afford more room for tracks. Soon an opening in the end wall was observed, and, in the hope of stopping the movement which was thought to be only near the surface, piles were driven in the terrace on the bank.

So far from helping the situation was the driving of piles, that it apparently caused the greater part of the slide by the jarring due to the fall of the hammer. A careful examination was then made and numerous borings disclosed the conditions to be met. A complete system of drainage was introduced with so much of improvement as to justify a continuance of the work.

Without knowledge to justify the argument, it was assumed that similar conditions would be found all along the lake front.

Opposite the Davenport Street slide, the tracks of the Lake Shore Railroad are 21 ft. above the lake level, and for many years have been so unstable as to require constant watchfulness and labor to preserve the alignment. This condition entirely disappears as we proceed westward, and westward of Muirson Street there has never been the slightest lack of stability in the tracks nor has there been any instability between Muirson Street and the river. The bank of the lake on this section has never shown evidence of instability, nor is there the slightest reason to apprehend any in the future.

The building site is not near a bluff, but is separated from the sloping bank on which is a city park, by somewhat more than the width of a broad street and from the bottom of the footings on the nearest front to the foot of the bank, which is several hundred feet from the nearest water of the harbor, the horizontal distance is nine times the difference of elevation.

There is no unstable soil on which to build, at this place, unless we needlessly go through the hard sand into the far less stable material which underlies it.

Where we have certain conditions and certain work to be done, there are two ways of proceeding. One is to try to adapt the conditions to the work, and this is not easy to do. Then to say that the conditions do not permit of our work is without good

reason. The other way is to adapt the work to existing conditions, and this offers no difficulty in the present case.

Let me seriously ask a question. In view of experimental information derived from practical work and experience, in view of these things which we know of a certainty here in Cleveland, does it appear best now to leave such solid ground of definite information and to start off on the unstable ground of untried experiment? — Not merely experiment for the purpose of obtaining information, though doubtless that would follow, but an untried experiment to use as a foundation for an expensive and monumental building.

DISCUSSION.

Mr. Lehman. — We desire to express to you our sincere appreciation of your invitation to take part in the discussion of the subject treated by Gen. J. A. Smith on some phases of foundations for buildings in Cleveland. The subject is one of great importance and I will not attempt to treat the matter generally, but confine my remarks as nearly as possible to the conditions presented to us as architects of the Court House, to which we have given considerable study, using the information furnished by borings, aided by various books on the subject, by consultations with engineers and contractors personally qualified for this work, and governed by our personal experience and intimate knowledge of the building requirements, as to varying loads to be supported and the depths of the excavations of which I will give a description without the plans; these have not been presented as requested by your secretary, owing to a difference of opinion of the members of the County Building Commission regarding the advisability of presenting details which might be beyond the scope of this discussion.

The plan of the proposed Court House building is of such symmetrical design that the walls might be described as a series of semi-detached piers, the piers and openings throughout being planned in regular panels and units, so that the loads to be supported by the foundations have been calculated in the same way as the foundations for isolated piers.

The loads have been carefully estimated, and diagrams and sections of all the walls drawn, the loads figured for the respective walls reducing the panel loads in each case to a pier load. In these calculations for the loads on the foundations, the dead load only was taken into consideration, good practice having fully demonstrated that the maximum dead load, but only a small

percentage of live load, reaches the footings in a structure of this kind. For this reason only the actual weight of the material in the walls, floors, and roofs was considered as being the load which causes a settlement of the foundation during construction, the loads assumed for the bearings of the soil leaving a sufficient margin for all the live loads which might be added, but which will not affect the work until long after the walls have been completed and long after the foundations have taken a permanent settlement.

From test pits and borings made for the County Building Commission we are informed that the soil under the building is of various strata down to clay, which is found at an elevation of about 40 ft. above the datum line, and that this elevation varied about 5 ft. Above the clay is a layer of quicksand varying in depth from 2 to 5 ft. and above this, fine sand, clay, and sand, and clay mixed with sand; below the 40 ft. elevation the clay extends to the lake level practically the same. These borings indicate that we have no solid ground, such as rock, gravel, or dry sand, but that we have a compressible ground described as clay and watery sand and mixtures of the two. The basement floor elevation is at 56.78; the heater room and elevator pit floors at 50.78; and the foundations will extend below these elevations to various depths depending upon the nature of the construction. The surface water was found to be at an elevation of 52.3 ft.

From borings made by the county surveyor we have further information that the clay elevation varies 7 ft. in height over the building site; that it is high at the west end and low at the east; it is not of a uniform stratum, but is rolling in both directions, the general slope being diagonally across the building site in a northeasterly direction, and forming pockets with a variation in elevation of probably 5 ft. in 20 ft. These pockets would seem to be of quicksand and water, and fine sand and water varying in depth in the same manner as the clay. Above the quicksand is a layer of sand and water to the elevation of 52.3, giving us a bed of this material in the water of from 4 to 8 ft. in depth, so that our lowest floors are below the water line, and our basement floor 6.5 ft. above the same. The building walls extend 1 ft. below the floor line so that the foundations would be partly in clay, partly in quicksand, partly in sand and water strata, and others in the sand above the water line, with a bed of sand varying from 1 to 7 ft. thick for those above the quicksand.

Other considerations regarding the site are the 4 ft. in

diameter Ontario Street sewer running through the center of the building at about the basement floor level, an 8-in. water main running parallel to the same, a 42-in. water main on the north side of Lake Street, and the bluff not more than 100 ft. distant to the north. The possibility of a break in the Ontario Street sewer may be imagined, but it is hardly possible to conceive what damage such an event might mean. Such breaks have occurred and may again. This sewer we intended to have rebuilt below our footings. This would remove the obstruction as far as the building is concerned, but would only increase the danger on account of the new excavation and filling below the foundation, and not remove the permanent menace of the sewer. The possibility of a break in the 42-in. water main located not far from the south line of the building, and the damage which would occur if this were not discovered or shut off for several hours can better be imagined than described.

These are the conditions of the site of which Professor Baker, in " A Treatise on Masonry Construction," says:

" The foundation is the most critical part of a masonry structure. The failure of works of masonry due to faulty workmanship, or to an insufficient thickness of the walls are rare in comparison to those due to defective foundations. When it is necessary, on weak or treacherous soils, the highest constructive skill is required to supplement the weakness of the natural foundation by such artificial preparations as will enable it to sustain massive and costly structures in safety."

On this site we propose to erect a building, not the ordinary commercial, store, or office building, nor a factory, but a monumental structure to cost several millions of dollars; a massive building of unusual size, of substantial character, heavy walls and stability, and one that should be a monument for this community; and it should be so constructed that it will be a permanent, safe and artistic structure that will withstand all possible ravages of external and internal conditions so far as man can reasonably and safely provide.

Should such a building be erected on sand and water, a semi-liquid, such as mud, silt or quicksand, which good practice says should be removed entirely or have piles, tubes or caissons through it to a solid foundation, regarding which Professor Baker says, " Soils of a soft and semi-liquid character should never be relied upon for foundations whenever anything better can be obtained."

Shall it be erected on sand above a bed of quicksand, on a sand cushion where the imposing weight of the structure will

compress the soft material into the varying pockets of mud, and uplift the other lighter parts of the buildings, or where there is a possibility that the imposing weight would produce a pressure on the water, changing the angle of repose and forcing an outlet at some point of least resistance? This condition is not only a possibility, but one of which there is well defined ground for apprehension, and one of which the same author says:

"The determination of the safe bearing power of soils, particularly when dealing with those of a semi-liquid character, is not the only question that must receive careful attention. In the foundations for buildings, it may be necessary to provide a safeguard against the soil's escaping by being pressed out laterally into excavations in the vicinity."

If this is true, what will prevent the soil from being pressed out at this bank to the north,— conditions which have recently occurred with much lighter loads not far from this site?

Who is to assume the responsibility of experimenting with the most serious part of construction, the foundation, which should be the best? It should be uniform; it should have a uniform and equal bearing, and should be as near as possible at a uniform elevation.

As it is impossible to build an unyielding base, the object should be to secure a foundation that will settle as little as possible and uniformly; and to secure this end the axis of the load should pass through the center of the area of the footings. This cannot be done to such fineness of calculation as with a steel bridge construction, but the effort should be in the same direction and for as good reason; for the more nearly uniform the construction and bearings, the more nearly equal will be its settlement, and the more permanent its stability.

That there will be a settlement we must admit; but to keep that limited and uniform is our problem. In ordinary, every-day practice, we do not hesitate to remove any inferior soil we may encounter in an excavation to such depth as to secure a natural solid ground and fill in the excavation with clean sand or concrete, this depending always upon the character of our building; and our clients surely expect that we do so, and would rightly blame any architect or engineer for building over a known soft or inferior ground.

It has been said that if the ground were properly drained it would be a solid foundation. This is true to the extent that the drained area can be kept drained; that all surface and natural water will be permanently removed, and that no springs exist, and that no artificial leakage can occur. If this can be done,

authorities will agree that the ground is suitable, provided that the expense should not exceed the commercial value of the work done, and results obtained.

Below this sand, water and quicksand referred to we have a deep bed of clay of uniform consistency, fairly dry, with a sustaining power equal to any load we may wish to impose; a really fixed value for foundations, and it does not matter whether this clay is good for 1 ton per sq. ft., 6 tons per sq. ft., or any other fixed value. Its value can be ascertained, and when fixed provides the material we are looking for, — a uniform ground of great depth upon which calculations can be made with an assurance of such stability as its character and value permit, and the only foundation worthy of consideration.

If the clay is soft, Bauman says in his "Treatise on Isolated Foundations": "We may consolidate the soft or unyielding ground by driving piles into it until it becomes so compressed that the piles are prevented from sinking by lateral friction."

We also quote from Freitag's "Book on Engineering," as follows: "Experience has shown that after clay has been compressed by a load of 3 000 lbs. per sq. ft. and allowed several months' repose, no very perceptible addition to that compression will result without a material addition to the load."

In view of the conditions as here established and the results of all of the information obtained, we have come to a conclusion and have submitted to the County Buildings Commission our recommendation for a foundation with piles of concrete, considering that an indestructible pile is essential in a ground containing water, and where there is a possibility within a few years of a change in the sewer system, that may lower the elevation of the water from its position to-day. This plan we have recommended, and we believe it to be a good and safe foundation for a building of this character that can be had at a reasonable cost on this site.

At this time it may not be improper to quote from a letter to the County Buildings Commission of April 5, 1905, by Gen. Jared A. Smith, referring to the borings for the County Building site, as follows:

> "It may not be improper here to mention the probability that it may be found desirable to support the foundation of the building upon some indestructible material which shall extend to or into the hard clay substratum in such a way as shall preclude any reasonable possibility of injurious settlement."

Since the plans have been made, the Ontario Street sewer question has been taken up with Mr. Hoffman, and there is now a

possibility of this being removed and the sewer diverted so as to drain to Seneca Street.

In conclusion let me say that it seems but proper that the question of the stability of the Court House, and in fact the whole grouping scheme, should be thoroughly investigated, and that I hope the County Buildings Commission will some day be able to arrive at some plan that will be feasible with consistent economy, so as to maintain the artistic character of the group plan and prevent the possibility of there being a group of ruins in place of building.

Gen. J. A. Smith. — I would not impose upon your time further were it not that my name has been introduced, with a view, perhaps, to show an inconsistency in the fact that a man does not know as much one time as he does at another. In a more recent letter to the Buildings Commission, I stated that when that matter first came up I did think that it might be possible that we might require something better than we had, but I said that from that moment I had not passed a hole in the ground without examining it. I have not seen a building without looking for cracks in it. I have not heard of a source of information that I have not gone for it. I have talked, not with all of you gentlemen, because that would be beyond the range of physical ability, but have talked with quite a number of the civil engineers and with some of the architects, and so stated; but as some of the commission seem to think that that was second-hand information it seemed best to get it at first hand and I have got that now.

[General Smith here read quotations from different letters.]

Mr. Osborn says, "My judgment is that the conditions and situation require that a spread foundation be adopted."

Mr. Ritchie gives me essentially the same thing, covers the same points. In order to get this officially I went to the city engineer. [Reading.] "I would consider the soil at 20 ft. capable of sustaining a load of 2 tons per sq. ft. without any danger and would not consider it necessary to use piling with such load."

Walter Rice tells me he has carefully digested all these available data and says, "I have no hesitancy in stating that the solution of the problem lies in deep drainage, the foundation of the building to rest thereon." After Mr. Rice had written that letter, I said to him perhaps there were not any two people who would give the same interpretation to "*deep drainage*," and he turned over the sheet and wrote:

"*My reference to deep drainage in the above means drains to be not less than* 2.5 *ft. below the footings.*" In other words, he meant to drain the water from them, so that if you come clear down to that very fine sand, even the most timid need not be afraid.

The Cleveland Engineering Company states substantially the same, and tells me about the weights underneath their columns in the Arcade power plant, and the fact that in boring their holes for the foundations of their building in Hickox Street, the borings were made with a 4-in. auger and in none of the borings were casings used, and yet each time the auger was put back it reached fully to the depth it reached before being taken out.

Perhaps you will bear with me a little more. We read somewhere of people who walked on the water. None of us have been able to do it much this winter, but when you get a little ice on the water you have something that is a fair illustration of a hardened coat of sand over a soft material, and when you get a few inches, a horse may walk on the water. Many years ago, twenty-four or twenty-five years ago, I commenced the work of one of the heaviest lighthouses on the Atlantic Coast, 60 miles south of St. Augustine. I had been telegraphed for to take the place of General Babcock, and I found the lighthouse in the condition that it was built up to the surface of the ground. I hunted up the borings and found from 12 to 15 ft. of a sand that was nothing like as hard as sand we have here, but was made of broken shell and pulverized coral. That sand overlay a swampy condition. To detect settlement should it occur I had 4 holes dug in the sand 3 or 4 ft. deep and bricked up like a well. A concrete foundation was put in the bottom of each of these holes, and on that material stones were set for bench marks. Observations were made daily but no settlement was detected. Last winter I was up on the top of that lighthouse again where it has stood for more than twenty years on a coat of sand overlying a swamp and there has not been one particle of disturbance in its foundation, notwithstanding it has stood in the vibrations of the heaviest winds that frequently traverse the coast.

Mr. Hanlon. — No doubt there are a great many yet who would like to take part in this investigation, but the hour is late and I move that the further discussion be postponed for two weeks, when we have a semi-monthly meeting and we can take up the subject again.

Mr. Lehman. — I would like to suggest to the members of the Club that as they are trying to take this up they address

the County Building Commission for permission to take the plans and have them here and go at the matter in a systematic way. If this club wishes to get at the facts let us get at the question in discussion.

President Green. — The discussion was to be a general discussion of foundations, although, of course, the Court House site and foundations are of general interest to all.

B. F. Morse (*read by Secretary*). — During the last meeting of the club, February 13, 1906, Gen. J. A. Smith in his remarks about foundations of buildings in Cleveland, referred to a test pile that had been driven down on the site of the proposed new County Court House. A pit was excavated down to ground water level, 20 ft. 4 in. below the grade of Summit Street to an elevation of about 48.8 ft. above the water in the lake. The pile was 37 ft. 4 in. long, 15 in. thick at the butt and 8 in. at the point. This pile was driven with a hammer weighing 2 680 lb., falling 21 ft.; during the last 4 blows the penetration of the pile averaged per blow 1.56 in. After the pile had been driven, the pit in which it was located was excavated deeper, about 9 ft., leaving so much of the pile above the bottom of the pit. The pile was then loaded with over 14 tons. In two weeks it had sunk 3 in., and during the last two days it sank more than in the previous twelve days. It occurred to the writer that it might be interesting to the club on this occasion, and perhaps aid somewhat in the discussion of the subject matter of General Smith's remarks on foundations, to give a brief history of the pile driving under or in the foundations of the Superior Street viaduct on the west side of the river.

Commencing at the west end of the draw or swing bridge at pier No. 8, thence westerly, there are 8 arches 83-ft. span and 2 97.5-ft. span. There are piles under 9 piers from pier 8 up to and including pier 17. These piles were from 30 to 45 ft. in length and were driven with a 2 500-lb. hammer, which for the last blow had a fall of 40 ft., causing the piles to sink on an average of 3 in. in pits 8 to 13 inclusive. In these pits on the river flats the material was composed of sand, river silt and mud for a considerable depth, mixed in different proportions even in the same pit. Occasionally the sand would be nearly pure in a limited area and 4 or 5 ft. in thickness, and frequently when a pile showed great resistance in passing through, it then would go down 8 to 15 ft. before it would again show the same resistance. This lack of uniformity made it necessary to change frequently the length of the piles, and also to vary their distance apart, to

get the requisite supporting power to carry the superstructure. Pits 14 to 17, inclusive, were entirely in the blue clay, apparently the same as on the east side of the river. The piles went down under the last blow in these 3 clay pits on an average of 5 in. In pit 14, the resistance was less than in the others.

The first piles were driven in the northerly end and when the driver reached the southerly end, a distance of 80 ft., the piles first driven had risen from 6 to 8 ft. and from that down to less than 1 ft., as they approached the southerly end of the pit. After standing about two months they were driven to the original depth, offering twice as much resistance in the second driving, as in the first. In some of the other pits the piles rose, but not as much as in 14.

In pits 8 to 13, the earth became consolidated in driving and offered greater resistance as the work progressed. But in the blue clay the last pile drove as easily as the first. Piles in pit 14 were driven 27 in. between centers and in the others from 28 to 36 in. The total lineal feet of piles used in the building of the viaduct was 242 767 ft.

The piles were cut off below the surface of the water in Lake Erie, and the material in and around the heads of the piles was excavated or removed to a depth of 1 ft. and the space filled in solid with concrete which was leveled off even with the top of the piles; then oak timbers 10 by 12 in. square were laid on top of the piles, leaving a space of about 1 ft. between them; these spaces were filled in solid with concrete and leveled off with the top of the timbers. Then a grillage of 10 by 12-in. oak timbers laid close together was laid crosswise on or over the entire surface; on this grillage the masonry was built. The permanent weight on some of the piles is as much as 20 tons; and the weight per sq. ft. of surface covered by the footing courses in some of the foundations exceeds 5 tons.

Test levels were taken on the footing courses of all the piers and abutments before and after they were built up to the springing line of the arches at intervals of from six to twelve months, until the viaduct was completed, the roadway paved and the full or permanent load placed upon the foundations, and yearly thereafter up to 1882. The viaduct was completed and opened to public use December, 1878. The first test levels were taken November, 1875. A period of about three years elapsed while this part of the viaduct was being built, and the settlement that took place during the three years as shown by the test levels was 2.5 in. at pier 8 and 3.5 in. at pier 14, the others

ranging about the same between the two. In the solid clay, foundations under piers 15, 16 and 17, the settlement was 5 in. From the time this viaduct was completed, for a period of four years afterwards, only about $\frac{1}{2}$ to $\frac{5}{8}$ of an in. settlement had taken place, as shown by the test levels.

During the building of the Walworth Run sewer, which for the greater part of the way is built upon this kind of blue clay, two expensive and scientific tests were made to determine its supporting power. The conclusion arrived at was that not more than 2 tons per sq. ft. could be applied to this kind of materials without danger of serious settlement. (See report of Mr. Walter C. Parmley, on the Walworth Run sewer, published in *American Society of Civil Engineers Transactions*, for August, 1905.)

From the above experiences, it appears that piles driven in this blue clay will not carry as much of a load as the sand and gravel overlying the clay, which agrees with the conclusions arrived at by General Smith. In the proposed new Court House and City Hall, the outside walls will be thicker and heavier but not nearly as high as some of the skyscrapers up town, so that the weight on the foundations of these proposed structures need not be any more than under the skyscrapers. The Society for Savings building is proportioned for 2.5 tons per sq. ft. on the foundations and they are only 12 to 14 ft. below the sidewalks, entirely above the ground water level. In the New England Building, the highest in the city, the foundations are not excessive, neither are they in the Rose nor Schofield buildings. They show no signs of settlement as yet.

From observations and experience, the writer believes foundations resting on the sand above the water and down into it, if they are not loaded over 3 tons per sq. ft., will be perfectly safe, and will not be as expensive as piles.

As to any danger of caving or sliding off the bluff northerly of Summit Street, or farther south, the writer knowing the conditions that have existed and taken place on the Lake front since 1851, especially between Seneca and Erie streets, has no hesitation in saying that in his judgment it will be perfectly safe not to use piles under these new buildings.

It is true that previous to the building of the railroad tracks and stone and pile breakwater, just outside of them down at the foot of the bluffs (but not since), landslides used to take place frequently, caused by the undermining action of the waves of Lake Erie during the storms from the northwest or northeast.

I could refer to many other foundations but I do not wish to take too much of your time.

I trust you will pardon me if I now digress somewhat from the matter under discussion, though rather late, to the life and cost of the proposed public buildings. Why should we build such expensive buildings when, judging from the past, most of them are too small or out of date inside of thirty or forty years?

For instance, take the old Court House, northwest corner of the Public Square, completed in 1858, only forty-eight years ago. At that time it was considered A No. 1. It has been enlarged and improved and is still very unsatisfactory. Then take the recent addition on Seneca Street; it was occupied in 1875. At that time it was considered a grand affair. Then again take a look at the present City Hall. At the time it was completed in 1875 it was, for this part of the country, a fine example (from outside appearance) of Mansard roof construction. The cut-stone work of the exterior is first-class; although the proposed new buildings will be of a different order, I doubt if the cut-stone work will be equal to it; yet there is talk of tearing it down in the near future. All these old buildings are not what is wanted now. All of them are deficient in light and ventilation in their interiors. But you may say that the most modern buildings that are being built now cannot be exceeded.

Suppose an architect or an engineer, fifty or even thirty years ago, had said the day would come when you would see the construction commence at the top story in laying brick and terra-cotta work, or at the third story and work upwards, which is a common occurrence now-a-days. You would probably have thought him a proper subject for an insane asylum.

I could refer you to buildings in other cities that are out of date which are to be replaced. In fact, it is a common occurrence in this country, and if they are to be cast aside in thirty or forty years or even fifty years, why spend so much money on them?

President Green. — Mr. Morse's discussion is very interesting. We have a lot of people with us to-night who are interested in this subject and a lot of people who have valuable information to give us. I trust we may have an interesting discussion. I shall be glad to hear from anybody.

Mr. Lehman. — In regard to the test pile that Mr. Morse refers to, and also the same one that General Smith spoke of, I just want to say that the failure of that pile was not due to the loading. As Mr. Morse explained, that pile was extended to about 9 ft. above the pit. When the extreme settlement

came after the load had been put on, it was discovered that the pile was tipping and at that time the loading was abandoned. The pile as a *test* pile was a failure.

Mr. Hoffman. — I think there is a point we should not lose sight of in speaking of pile foundations. I speak of the large number of piles driven in the pits of the viaducts. The first drive was 2, 3 to 4 in.; the second driving was much less. It shows that the ground becomes closely compacted by driving a large number of piles in a limited area. I think it is a little far-fetched possibly to attempt to draw too many conclusions from the single test pile. It seems the only way to do is to drive a a cluster of them at least and get the increased bearing and not to draw too many conclusions on one pile. When you have a large area under consideration you certainly get different results from what you do when it is a small, limited one.

Mr. Morse. — In regard to pit 14, if the piles had been re-driven immediately I think they would have gone down much easier; but after standing two months they were re-driven with difficulty.

The Secretary. — I have some notes here that General Smith telephoned to me this afternoon. He is sick and has been confined to his home for several days and cannot be here.

In the first place, he presupposes that the piles as designed for the Court House foundation are limited to 24 ft. in length; and from further information he has ascertained, or at least he deduces, that in the interior of the Court House there would be as wide a variation as from 14 to 24 tons per pile, and on the outside walls as wide a variation as from 15 to 30 tons for a single pile. He cites again the Kirtland Street smoke stack, which was put up on a pile foundation, these piles being 35 ft. long. On these piles there is a weight of 12 tons per pile. There has been a settlement of from 0.5 to 1 in. and very unequal, the weight having been equally distributed.

He makes the further point that in the Court House an average of 21 tons is estimated for, and this is very unequally distributed, so that he figures it is probable that the weight on one pile as designed might be 90 per cent. less than the weight on other piles.

[N. B. A careful examination of the plans since the above discussion, by General Smith and myself, shows a variation in load of from 15 to 38.4 tons per pile. — Secretary.]

Mr. Lehman. — I am sorry General Smith is not here, because what I have to say I would like to have him hear.

In the first place, I will say that I do not know where he got those figures from, but they are not right. The Court House piles are figured on as nearly as possible at 25 tons to the pile and not at 24 ft., but 30 ft. long.

As I said two weeks ago, I was sorry that I could not bring the drawings of the Court House here, and it was our intention to bring them. Five members of the committee were very willing that the details and the plans should be brought here and explained to the club, but two members objected, and I do not hesitate to say that General Smith was one of them, and one of his objections was that the probability was that his paper would not take up the details of the Court House specifications or plans, and that the details of the building would probably be beyond the scope of that paper and ought not properly to be discussed here; and another member of the commission also objected to the plans being brought here because the plans had not been adopted by the commission.

The facts in regard to the Court House foundations are about like this: In the first place, we laid out a foundation for that building with the beams going across the walls and constructed you might say almost practically as isolated piers. The only connection is a little strip under the opening, probably 3 or 4 ft. long; and then we are figuring for a uniform load notwithstanding any remarks General Smith or anybody else may make. We have diagrams to show the load of every pier in the building, not only sketched out but drawn out, and the loads carefully figured, and those loads are all submitted to the engineers who designed the foundations. I think they are figured as near right as can be on those loads.

Those plans included a deep draining system outside of the entire building, probably 10 ft. beyond the area wall, which would bring it probably to 25 ft. away from the main wall of the building; and this drain went down into the clay with a sewer pipe at the bottom and a stone and cinder filling and a complete drain to the sewer to keep the entire site of the building as dry as possible. That was the first plan, but that was finally abandoned for the reason that there was no assurance that the drainage system or that deep drain that we had there could be maintained. It would do all right for a little while, but nobody could say how long that would keep the place dry, and after a great deal of figuring a pile foundation was designed and estimated on; and the difference between the cost of the grillage foundation with the drain and the pile foundation without the drain, was not

so much as to make an impression on a building of that size. That was the plan that was submitted with the drawings.

The Buildings Commission had that plan under advisement for some time and finally sent us a communication instructing us to eliminate all specifications regarding pile foundations and insert therefor a specification for a concrete spread footing foundation with 9-in. drain 2 ft. below the footing and 6-in. branch drains every 20 ft. along the building connected to the 9-in. pipe and the 9-in. pipe to drain into the sewer. That was specified in detail by General Smith's resolution.

We prepared a foundation plan of that kind. Then they considered that plan. We have a fourth foundation plan for the Court House now, where the footings, instead of being isolated, are continuous, connected both ways so as to make it sure they cannot get away. That is the last plan. This last one is without drains. General Smith thinks that is pretty good even if there are no drains in it. He thinks, too, that a grillage foundation might be good even without drains but a spread footing of concrete only would not be any good without drains.

General Smith, in speaking of the Rockefeller Building, said that they bored a hole I don't know how many feet below the foundation and no water could get into it. He also said that if you would drive piles on the Court House site the water would percolate all the way down those piles. I would say that the plans for the Court House do not say that any single pile is to be tested. They are to be tested in groups of four. The piles are estimated at 30 ft. long.

The Secretary. — What was the difference in cost between the grillage foundation and the pile foundation?

Mr. Lehman. — I have not got the figures and I do not want to be quoted in figures without the direct estimates, but I think one figure that was given out, the difference between a pile foundation and the concrete foundation without drains, was $56 000. The difference between the grillage foundation with the drain I do not remember, but the pile foundation is more expensive than the grillage. I do not know just the exact amount, but there was much more steel in the double grillage, and proportionately more concrete.

Mr. Olmstead. — What was the level of the base of its foundations as regards the adjacent streets and also the lowest level of basement?

Mr. Lehman. — The grade elevation there is taken at 70.5. I think our basement floor level is 56.78 and the elevation of our

heater rooms is 50.78. The elevation of the surface water there, 52.3. The wall itself is about 1 ft. lower than the floor; 50.78 is our lowest, whereas the grade elevation is 70.

PRESIDENT GREEN. — Mr. Lehman, in the test of the ground, do you remember what the average elevation of the clay is?

MR. LEHMAN. — The elevation of the clay at the west end of the building I think was 45; in the center of the lot 42 or 43, and at the east end 40, and by other borings made at different parts of the building we have a variation anywhere from 40 to 47 ft. and that varies sometimes; one pit will be 40 and another, 30 or 40 ft. away, may be 45 or 43 or 44 ft.; these pits were made on a line north and south; the elevations of these go to show, I think, the highest point is near the center, 47; 45 at the west and about 40 at the east and the general slope of the clay is in a northeasterly direction, diagonally across the building.

PRESIDENT GREEN. — I do not know whether I can say anything at all new to the members, but, illustrative of the point of the whole matter, we might have before us a few points regarding the subsoil through Cleveland in this territory as follows:

Quite a number of tests have been made in different places and those tests combined with the reports of geologists agree fairly well that the subsoil from the surface is sand, growing generally finer as you go downward, for varying distances of perhaps from 25 or 30 to 50 ft. below the surface; that at some point between those limits, the dark, hard and fairly dry blue clay is reached which is known hereabouts as the Erie clay, and that that clay continues generally to a depth of 120 to 200 ft. below the surface, that is, making a total thickness of the clay of perhaps 60 or 70 to 150 ft. That clay is generally reported to be somewhat stratified in its nature and generally quite dry. It contains occasional pockets, sometimes of quicksand and sometimes of a finer and more moist clay and occasionally of shale formations. The peculiar stratification of the clay is indicative of the Erie clay; underlying that is the Erie shale, which is quite thick. It is that dark blue, slaty sort of rock, often called soapstone, that has the peculiarity of disintegrating on contact with the air. It is quite hard when first uncovered but will go all to pieces in a short time on exposure to the air. I have seen that checked up in a number of places; that is, so far as the Erie clay is concerned.

In the flats where two deep borings were made below the

level of the flats, the clay is much lower, and one goes through sand of quite varying consistencies and mud and all sorts of things; one hole that was put down at that point was driven 48 ft. through casing and, inadvertently, the boring tool was allowed to get pretty close to the bottom of the casing and we never got the tool back. It stuck too tight to pull out. The soft muck and quicksand of that territory came up and filled the casing nearly to the surface. The sand through most of this business district is a reddish yellow color, growing somewhat finer with the depth, and after getting into water-bearing stratum becomes a bluish gray color.

We have then a sand soil 30 to 50 ft. thick, with clay underlying it. The clay is dry, the sand in its lower part is wet and is dry above.

So far as any tests that have ever been made are concerned, the bearing power is good throughout the sand, in fact, the bearing power is a little more secure on the sand than in the clay, and I think the members will bear me out in the statement that, as a general rule, sand is a better bearing soil than clay, even though the clay may be fairly dry. The sand if it is wet is a better bearing material, provided that the fine sand, when it is wet and mixed with enough lubricant to make it what we commonly call quicksand, is confined laterally.

I think the point that General Smith brought out of the percolation of water running down the side of the piles in clay was about right. Piles will drive easier in clay than in sand. We all know that clay is a very poor bearing soil if it is at all wet. The surface of the clay against the pile becomes greased with water that is carried down with the pile. My understanding of the geological condition of the moisture of a good deal of the soil hereabout is that the water lies on top of the Erie clay in pockets or low places on that surface.

Mr. Lane. — It is a little bit off the subject, but in regard to the geological condition of the actual valley here, the original mouth of the Cuyahoga River was along Willson Avenue and was about 500 ft. deep at that point. In drilling gas wells they went 500 and some odd ft. before striking the shale, and less than one mile east they struck the shale at about 45 ft. From drillers who have drilled over a hundred gas wells in that district, I have heard that the old river bed is filled with silt and clay, and there are some pockets filled with quicksand. Our city is fortunately located in that our heavier buildings are on shallower depths of the Eric clay. If we were 3 miles east-

ward, it would be on the solid shale. The Erie clay is a glacial formation.

Mr. Lehman. — I would like to ask Mr. Morse a question. There have been banks recently that have slid off west of here out along Lake Avenue. We know that the bank there has slid off into the lake in pretty good chunks. It may be possible that Mr. Morse may recall that about fifty years ago there was an immense slide all along the lake and that it went down north of here 25 ft., and that practically the whole bank along the whole front of Cleveland went down at that time. I was wondering if Mr. Morse would remember anything about it.

Mr. Morse. — The bank did not go down uniformly the whole length, but would go down in sections, 100 or 200 ft. long; some would be 10 ft. on the surface and some may have been 20 ft. wide, more or less, but that was before any piles or railroads were built down there, and there were no depots or breakwater out there, and the waves came in during storms and undermined the foot of the bluffs, and they would slide down in places at different times. When the water was very high, as it was at one time, the banks caved away much faster; but since the railroads have built there and the breakwater is just outside the railroad tracks, the waves cannot get at the bluffs, and there have been no slides.

Colonel Whittlesey says that Erie clay is shown to be principally a fine sand with clay enough to cement it. It also contains lime enough to give it a lime character and when soaked in water becomes soft and yielding like quicksand. I know from experience; I have worked a good many times in this blue clay. When we were building the depot we had a steam shovel, and in places it had to be picked down by hand, that is when working it from a perpendicular face; but you take off the sand and gravel on top and you can shovel it up. There is a little moisture in there, and by putting on teams and driving over it, it works up and you can shovel it; but if you work it down below, you have to pick it down.

Mr. Lane. — The action on that Erie clay can be observed in the present mouth of the Rocky River. It is Erie clay with gravel overlying and you will find every year the waves undermining the Erie clay and chunks of the bank sliding down. There were two marked slides there last year. The same thing must have occurred here at the time the lake could get at the bank. But now that the bank is protected I can see no way for it to slide. I do not believe a man could pile enough on it to

make it slide. But a little bit of undermining would take it down.

Mr. Schowalter. — From the last paper I had this impression, — that there was fear on account of settling that might be caused by the pockets of quicksand which General Smith tried to prove was not quicksand. I notice that the Baltimore & Ohio Railway have made their tunnel in Baltimore secure from quicksand dangers by driving pipes every 100 or 200 ft. along the tunnel and pumping cement gravel in the quicksand, thus solidifying it. That was about a year ago, and previous to that the water had found its way along the tunnel and carried along with it some of the quicksand and caused some settlement along the right of way, and the city compelled the railway company to do something to prevent the water carrying the quicksand along the tunnel and this was what was done. I should think, in a foundation, wherever it is placed, if this is possible along the tunnel it could be done here. If there is any danger of quicksand it is an easy matter to run pipes into it and solidify it.

Mr. Olmstead. — As regards draining of the foundations and also concerning solidifying quicksand, I was interested in watching the construction of the Erie Street sewer. The Erie Street sewer ran into sand which, if not a quicksand, was a mixture of sand and water which I should call a quicksand. There are no drains I believe under this building. There are no drains I know under the Citizens Building and there has been no settlement there, although the foundations are grillage foundations laid on the sand. It is presumable that the conditions are the same in the one next to it. It seems to me that that has a bearing on the necessity of drains under any foundation of grillage conditions such as we have under the Court House.

PROPORTIONING CONCRETE.

By Sanford E. Thompson, Member of the Boston Society of Civil Engineers.

[Read before the Society at an informal meeting, February 14, 1906.]

As the uses for concrete increase, the necessity grows for a greater economy in construction. To reduce the cost of materials one naturally considers the use of leaner proportions. To decrease the proportion of cement without corresponding loss in strength the aggregate must be specially graded or such materials selected as will increase the density of the set concrete.*

Just how far it is economical to go in increasing the density depends upon the conditions. If, as might be possible on a small job, the cost of materials is reduced 10 cents per cu. yd. by substituting a leaner but denser mixture, and, at the same time, if the cost of labor of preparation is increased by 15 cents per cu. yd., it is obviously poor economy. It may, in fact, sometimes cost more in time and trouble and materials to make a lean concrete of high strength than to attain the desired result by using more cement and the materials nearest at hand.

On the other hand, if a large mass of concrete is being laid per day, it may be good economy to spend money for special tests and provide extra machinery for preparation, and even to pay a higher price for the sand or stone in order to secure that which is best suited for the work. The question then is one which must be settled by estimates of cost, and the size of the job is the chief determining factor.

However, special grading of materials is a matter which interests us much less frequently than the practical selection of proportions for structures where the choice of aggregates is limited and the character of the concrete such that the problem is simply one of selecting the best relative proportions of the available coarse and fine aggregate, or, perhaps, comparing two materials which may be obtained at trifling difference in cost.

* The term *density* I use in its now generally accepted meaning, as the ratio of solid particles in a unit volume of concrete. It is thus the complement of the voids. For example, if a piece of concrete has 15 per cent. voids (including the air and the water), 85 per cent. of its volume must be solid material, and its density is 0.85.

Therefore, before considering the effect of different characters of aggregate, we should first study the experimental methods for proportioning two materials and for simple comparisons of quality.

In experimental determinations for selecting proportions it is a generally accepted fact that for maximum strength we should aim at a mixture having the smallest percentage of voids, but it is by no means settled as to *how* this result shall be obtained even experimentally. For convenience in studying the question we may classify the various plans which are followed.

(1) Arbitrary selection; one arbitrary rule being to use half as much sand as stone, as 1:2:4 or 1:3:6; another, to use a volume of stone equivalent to the cement plus twice the volume of the sand, such as 1:2:5 or 1:3:7.

(2) Determination of voids in the stone and in the sand, and proportioning of materials so that the volume of sand is equivalent to the volume of voids in the stone and the volume of cement slightly in excess of the voids in the sand.

(3) Determination of the voids in the stone, and, after selecting the proportions of cement to sand by test or judgment, proportioning the mortar to the stone so that the volume of mortar will be slightly in excess of the voids in the stone.

(4) Mixing the sand and stone and providing such a proportion of cement that the paste will slightly more than fill the voids in the mixed aggregate.

(5) Making trial mixtures of dry materials in different proportions to determine the mixture giving the smallest percentage of voids, and then adding an arbitrary percentage of cement, or else one based on the voids in the mixed aggregate.

(6) Mixing the aggregate and cement according to a given mechanical analysis curve.

(7) Making volumetric tests or trial mixtures of concrete with a given percentage of cement and different aggregates, and selecting the mixture producing the smallest volume of concrete; then varying the proportions thus found by inspection of the concrete in the field.

Still further variety in methods is produced by different handling of the stone and the sand, some engineers measuring the voids in the stone loose, while others compact the stone to a greater or less degree. Other complications are introduced by the different methods of determining voids, whether by pouring water into the stone or sand, pouring the stone or sand into

water or weighing and calculating the voids from the specific gravity.

After the proportions have been selected, the questions arise as to whether we shall frame the specifications to require loose or packed measurement of the aggregate, loose or packed or arbitrary measurement of the cement, or weight measurement of all the materials; or shall the specifications state that the concrete shall contain a certain quantity of cement in a cu. yd. of concrete? Shall we adopt two aggregates, merely sand and stone, or shall we mix two grades of sand and two grades of stone? These are some of the problems which confront the man who would proportion his concrete for maximum economy.

At the outset we must admit that the nature of the materials used in concrete, the daily and even hourly variation in the quality, sizes and percentage of moisture, prohibit absolute accuracy either in fixing proportions or in practical measurement of materials. Yet different methods of testing for the purpose of fixing proportions in advance may produce, with the same materials, as great variation as between 1:2:4 and 1:3:7½; surely such possible variations are not to be ignored. Differences in the methods of measuring proportions by the contractor may produce nearly as great variation.

It may be well to review first the causes of the variations in tests for proportions, the sources of errors and the part which good sense and careful judgment must play in the matter. Suppose we consider what may be termed the ordinary method, which is most commonly given in print and employed quite widely in practice,—the method of first determining, separately, the voids in the stone and the voids in the sand, and then proportioning the volume of the sand equivalent to the voids in the stone and the volume of cement slightly in excess of the voids in the sand. The chief variation in the stone, if it does not contain sand or dust, is due to the degree of compacting. Some adopt loose measurement and others packed, while many use slightly shaken measurement. One man may measure broken stone *loose* and find 50 per cent. voids, while another may take the same broken stone and, compacting it, obtain 40 per cent. voids. The proportion of sand in the two cases, if selected strictly by the test, will vary accordingly. The size of the measure also affects the voids.

The voids in stone above ⅜ in. may be correctly determined either by pouring in water, or by weighing and calculating from

the specific gravity. In either case, if a porous stone, correction should be made for water absorbed in the pores. Most rock in this vicinity is so dense that this absorption may be neglected. If the stone contains dust, even a small proportion, the air is held in the pores and inaccurate results are reached. Accordingly, for fine material, it is more accurate, in fact necessary, to adopt the weight and specific gravity method. This is also the simplest method with sand, as the specific gravity of sand averages about 2.65. In the vicinity of Boston I have found it slightly higher than this, ranging near 2.7, probably owing to the pieces of trap and other heavy rock contained in it. Either figure is sufficiently accurate to use for void terminations, provided one desires to test the voids. The moisture in the sand must be corrected for by drying a sample and determining the percentage of moisture.

It is thus comparatively easy to find the voids, both water and air voids, in a certain sample of sand, but when we come to figure from these voids the proportion of cement to select, we meet with a greater difficulty than in the relation of the stone to the sand. How shall we select the sample of sand? Shall it be dry or moist, loose or shaken, measured in a small measure or in a large one? Every one of these variations will give a different ratio of cement to sand. Examples of actual tests in my laboratory show that in ordinary bank sand with natural moisture, there may be a difference as great as from 53 per cent. voids when the sand is measured loose to 42 per cent. after shaking.

The effect of moisture on Cowe Bay sand came to my notice in a practical way in connection with tests at Jerome Park Reservoir last winter. In order to make an entry upon one of the tables, although not for direct use in the experiments, as we considered that a knowledge of the voids in sand was of little value, a sample of sand which had been dried in the laboratory was weighed. Its weight was found to be 103 lb. per cu. ft., corresponding to 38 per cent. voids. The same sand was then placed out of doors during a rain, and after lying in the sun for two days following, was retested, and found to weigh 83 lb. per cu. ft., corresponding to 52 per cent. voids. By the theoretical method of proportioning, in one case the proper mortar would be about 1:3 and in the other case about 1:2, and yet the sand was the same and, therefore, the 1:3 mortar would have been only about two-thirds as strong as the 1:2.

I made the statement a few minutes ago that different

methods of testing might result, with the same materials, in proportions as widely different as 1:2:4 and 1:3:7½. The case cited shows this difference in the mortar. The difference in the ratio of sand to stone (*i. e.*, 2:4 in one case and 3:7½ in the other) may be reached on the one hand by measuring the stone loose and finding 50 per cent. voids, and on the other by compacting it before measuring the voids and finding 40 per cent. voids.

Perhaps I have dwelt too long upon the inaccuracies of proportioning, but it seems to me that this is a matter of the greatest importance to us in order that we may avoid such inaccuracies, or, at least, exercise very careful judgment in drawing conclusions from them. For example, in the case just mentioned, which is correct, the 1:2:4 or the 1:3:7½? In other words, shall we measure the stone loose or compacted, and shall we measure the sand dry or moist? Or shall we throw aside this method of determining proportions and select some other? As I shall suggest presently, personally I do not place much dependence upon the determination of voids in the different dry materials because of the variations I have mentioned. However, some information may be gained from such tests if the character of the materials is taken into consideration and the methods made to apply to them. For certain materials, for example, the stone may be compacted before measuring the voids and the proportion of sand thus formed, measured loose, will be sufficient to fill the voids when making the concrete. This is the case when the stone is coarse and of fairly uniform size, such as 1½-in. macadam stone, and contains no small stone. The voids are then large, and particles of ordinary sand will fit into them. On the other hand, if the stone is crusher-run, even with the dust screened out, and the sand contains a large proportion of coarse grains, many of these grains will be too large to fit into the smaller voids of the stone, and, therefore, will increase the bulk. Consequently, a larger quantity of the smaller grains must be had, and to do this, the total quantity of sand must be more than enough to fill the voids in the compacted stone. This question of the relative sizes of the grains, which I think was first brought to notice by Mr. William B. Fuller, is frequently neglected in fixing proportions.

This principle is well illustrated in the use of gravel and sand screened from it and remixed. Ordinarily screened gravel, measured loose, has about 40 per cent. voids, so that one would naturally expect a mixture of, say, 1:2:5 to work satisfactorily. If the gravel is compacted so that its voids are 32 per cent., the

theoretical mixture would be 1:2:6. However, in practice, the grains of the gravel and sand overlap each other, that is, the smallest grains of gravel are smaller than the coarsest grains of sand, and the voids in the gravel are consequently too small for the large sand grains to enter, so that it is sometimes necessary to use half as much sand as gravel in order to prevent large voids in the concrete.

Experiments by Mr. Rafter, which are of very great value and have been widely quoted, show a surprisingly small proportion of sand. He used 35 per cent. mortar and 40 per cent. mortar both in test and in practice; *i. e.*, the volume of mortar was 33 per cent. and 40 per cent. of the volume of stone slightly shaken. Now, even the larger per cent., 40 per cent. mortar, corresponds to proportions with as little sand as 1:2:6, which probably none of us could use with our New England sand and make good concrete. Our materials would require a 1:2:5 or 1:2½:5 mix. However, if we examine the analysis of Mr. Rafter's sand, we find that 92 per cent. of it passed a No. 30 sieve (30 meshes per linear inch). The grains were thus small enough to enter the voids of the stone without appreciably increasing the bulk; in fact, in many of Mr. Rafter's tests, the volume of the concrete was considerably less than the broken stone slightly shaken. His sand, although apparently so fine, was not of bad quality for concrete work, because there was very little dust in it, and therefore the cement entered the sand voids.

We are coming now to one of the principal points which I wish to make in considering this subject of proportioning. The cases cited show that the experimental void determinations cannot be expected to give practical results, but various allowances must be made. Now, why not, instead of making tests one way or another, guessing at the best way to handle the materials and then altering the proportions by judgment, why not, in the first place, or, at least, after rough determinations to serve as a basis, make up trial mixtures of the materials with the stone and sand and cement and water, and determine, from the appearance of this mixture and the quantity of concrete made from it, and, to go a step further, from the density, or, in other words, the percentage of air and water voids which it contains, whether the proportions are correct? If only two materials are available, the proportions of sand to stone may be determined, after selecting the percentage of cement, by mixing the materials in several proportions and selecting the one giving the smallest volume with a given weight of aggregate (corrected, if necessary, for differ-

ence in specific gravities); also, judging by the appearance of the mixture, taking care on the one hand that there is sufficient mortar to fill the voids in the stone,—that is, that there is a slight excess on top when lightly rammed,—and, on the other hand, that this excess is not too great. The appearance of the concrete also should not be coarse, but there should be enough cement and fine particles of sand or dust to fill the pores and make a fairly smooth mortar.

In the field, this method of inspection is also applicable. In laying the reservoir bottom at Jerome Park, New York City, for example, there was more or less variation in the broken stone and screenings from day to day, and the inspectors were given authority to slightly vary the relative proportions of these two materials, always keeping the proportion of cement to total aggregate at 1 : 7, so as to give a mix which worked just right in place.

I will not go further into the methods of making these tests, because I do not wish to take too much of your time, but shall be very glad to answer questions in regard to them. Materials cannot be satisfactorily mixed dry by trial with ordinary apparatus and thus proportioned, because there is so great separation of the coarse and fine particles. Then, too, the addition of the water changes the relations, since a fine sand requires more water to produce the same consistency than a coarse sand, and consequently makes a larger bulk of mortar. Therefore, for the trial mixtures all of the ingredients must be used, including the cement and the water, as well as the aggregates.

The methods are very useful not only for determining the proportions of two materials but for comparing the value of different aggregates, and also selecting proportions where the aggregate is separated into three or more parts. I have just completed a series of tests for a client in which we found that by changing and grading the sizes of the particles, we could obtain a strength two and a half times as great with the same proportions of cement, while, on the other hand, we could maintain equal strength with 40 per cent. less cement. In connection with such combinations, the use of mechanical analysis diagrams and curves very greatly facilitates matters, and in many cases the correct proportions can be directly predicated in advance if the mechanical analysis curves, for the different materials are plotted from the sieve tests and combined. Mechanical analysis methods are eminently scientific and should be destined to greatly increased use both alone and as an auxiliary to other methods of testing.

From these somewhat general observations and from the results of tests which cannot be presented this evening, we may offer the following suggestions as guides to proportioning:

(1) The size of the largest stone in the aggregate should be as great as is consistent with proper placing of the concrete.

(2) If size of stone is small, a richer mixture must be used; thus 1:3:6 is a fairly rich mix with 2-in. stone, but a lean mix with ½-in. stone.

(3) If sand is fine, a smaller quantity may be used in proportion to the stone.

(4) For concrete a sand with too large a percentage of very coarse grains may be detrimental because they will not fit into the voids of the coarse aggregate.

(5) If the broken stone or gravel contains fine stuff, a smaller proportion of sand must be used.

(6) Better proportions are obtained in practice by screening the sand or dust from the coarse material and remixing in required proportions than by using the run of the bank or the run of the crusher.

(7) If the mortar in concrete is rich, say, up to 1:2½, sand should be coarse, with comparatively few fine grains. A lean mortar, on the other hand, is improved not only in strength but in smoothness of working, by using a sand containing dirt or dust.

(8) If fine sand must be used, the proportions must be richer than for coarse sand, because a fine sand makes a mortar of lower density.

A very important point still in question is with reference to the use of fine sand for water-tight work. A few permeability tests which I have made recently indicate that a slight excess of fine grains in the sand is often beneficial for concrete designed for water-tight work. For example, I greatly increased the water-tightness of a 1:3:6 concrete made with ordinary coarse bank sand of a quality to produce a strong mortar, by substituting for one-sixth part of the sand an equal weight of very fine bank sand. This fine sand decreased both density and strength and yet increased the water-tightness. A further increase in fine sand did not appreciably affect the water-tightness at an early age, but on longer time tests the specimen with the small addition of fine sand was much superior to those with a larger quantity of fine grains. In a 1:2:4 concrete made with coarse bank sand, an addition of fine sand did not improve it, evidently because there was a sufficient excess of cement to render more fine sand unnecessary.

DISCUSSION.

Mr. William Parker. — The question of what to write in specifications concerning the proportioning of concrete is an important one and will continue to be so until all are converted to the cost-plus-a-fixed-sum method of contracting work, and even then some written instructions will be needed for work which is being done at points at a distance from the headquarters of the engineer or architect.

As indicated in the paper of the evening, much depends upon the character of the sand. The old specification which called for sand to be " clean, coarse and sharp " is now generally considered obsolete for lean concretes.

We learn from Mr. Thompson's paper, from his book (Taylor and Thompson: "Concrete, Plain and Reinforced") and many other sources, that, within certain limits, dirt is beneficial rather than injurious to lean mortars such as are used in the concretes forming the greater bulk of our work.

We also learn that the next term used in the old specification, " coarse," should not stand as it is without qualification, especially for lean mortars. The words " clean and coarse " together have led to a tendency, on the part of those whose business it is to furnish sand, to deliver what should really be called a clean, fine gravel, with almost no fine material in it, and Mr. Thompson tells us that " coarse grains will not fit into the voids of the coarse aggregate." On the other hand, it has been the speaker's experience that a sand which is nearly all of good quality, but fine grains, although it will make a good looking, dense concrete with all parts of the stones well coated with mortar, causes the concrete to be slow setting, which is a very important matter where forms are being used repeatedly, and it is therefore desirable to remove them as quickly as possible.

The third term of the old specification, " sharp," it is now conceded, means but little, either practically or theoretically, although it is the speaker's opinion that the word " angular " might be substituted for it if the work is of a very particular nature.

In order that a contractor may know, when he is making up his bid, what the engineer will require as to the character of sand he is to furnish, something must be said in the specifications concerning it. The requirements of the specifications will also be a guide to the inspector on the work.

For lean concrete we have seen that the old requirement is more exacting than necessary in some respects, while for rich mortars for granolithic work or for structures which are to be watertight, the contractor will be required to make a more careful selection than for ordinary work, attended, in most cases, with additional expense.

The following specifications for sand for lean concrete are quoted from specifications written by the speaker for work done the past year and for some of the contracts which are to be executed the coming season:

"Sand for concrete shall be free from organic matter and shall contain but a small per cent. (not more than 7 per cent.), if any, of clay, subsoil or similar material. The sizes shall be, preferably, a mixture of coarse and fine, but no batch of concrete shall be mixed with wholly fine sand; that is, sand so fine that, after having the coarse parts screened out of a sample by the use of a No. 12 sieve, more than 50 per cent. will pass through a No. 50 sieve."

"No sand which comes out of the banks in cakes or lumps (dead sand) will be allowed in the work."

"Sand for concrete taken directly from the banks need not be screened if it does not contain more than 10 per cent. of pebbles which will be retained on a ¼-in. screen, and if the said pebbles are no greater than the maximum size specified for the different classes of work."

"The material which has passed through the ½-in. screens used in obtaining pebbles from coarse gravel shall not be used for sand for concrete without the addition of fine sand from other sources, so that it will be a proper mixture for filling the voids in pebbles or broken stone."

"Sand for facing and top-finish mortar shall be screened and perfectly clean and of medium size (somewhat coarser than brick mason's sand)."

It cannot be said that these specifications are altogether the result of experience, as, for instance, there has been so far but little, if any, occasion to consider the matter of cleanliness, as it has been so easy to get clean sand. The 7 per cent. mentioned as the allowable amount of clay, etc., is given simply to convey the idea to the contractor and inspector that a sand containing quite an appreciable amount of so-called dirt will not be rejected. Although it is now well known that a much larger percentage, even up to 20, is sometimes admissible, it does not seem wise to use any such figure in specifications for

contract work where but little opportunity will be afforded for careful watching or experimental work. The 50 per cent. in the last part of the first paragraph quoted had better be changed to 30 per cent., and this has been done in later specifications.

Specifications covering the matter of sand for artificial stone platforms are quoted as follows:

"The 1-in. thick layer of platform and 1-in. thick outer layer of curbing shall be composed of one (1) part Portland cement and one and one-half ($1\frac{1}{2}$) parts coarse sand, of the same character as the sample at the engineer's office at Boston and Springfield."

The sample referred to is clean sand, varying in size from little coarser than that which might be called dust to pea size grains. It is also angular. At times it has been necessary to do double screening to get what was required, and a very few times it has been necessary to do some washing.

Crusher dust has been substituted for the specially selected sand for the finish of artificial stone platforms with good results, but the surface is not quite so satisfactory in appearance.

In the paper of the evening the suggestion is made that "Better proportions are obtained in practice by screening the sand or dust from the coarse material and remixing in required proportions than by using the run of the bank or the run of the crusher."

In specifications for a concrete drain the speaker has called for broken stone free from dust and for a certain proportion of dust to be used with sand in making the mortar for the concrete, but for lean concrete the dust has been included with the run of crusher, the specifications being as follows:

"Broken stone for concrete shall be hard and sound, trap-rock, granite or other hard stone of a quality satisfactory to the engineer, free from dirt or dust other than that caused by the crushing of the stone itself."

"The broken stone for all work shall be the entire product of the crusher, including dust, up to and including the size which has passed through the crusher screen having a diameter of about two (2) inches."

"It is intended that the percentage of voids in the broken stone, including dust, shall be about 35 per cent. of the entire mass when moderately packed into place in the gaging-box mentioned below."

"The contractor is to provide and maintain in good order a watertight box which will contain ten (10) cubic feet, for the

purpose of determining, approximately, by experiment, the amount of voids."

"If the proportion of voids exceeds that specified, proper adjustments are to be made by the use of additional sand as directed by the engineer. An excess of dust over that necessary to reduce the voids to the amount specified shall be corrected by a reduction in the amount of sand used."

This method of including dust has been specified for several different jobs, amounting in all to about 40 000 cu. yds. of concrete, and has proved very satisfactory. For the work just referred to nearly all stone came in cars and was Westfield trap rock. The coarse stone is first run into the car, then the next grade and lastly the finest grade which includes the dust. The plant is so arranged that this can be done with little trouble, and other plants visited by the speaker could deliver in the same way almost as easily. The result is that each car has a very close approximation to the proper amount of coarse and fine material, for the man at the valves can estimate quite closely how much of each kind of stone to let out of each bin after a little experience. It is also practical with but little, if any, additional expense, to so conduct the work of shoveling out of the car into buckets or barrows that a fairly uniform mixture is maintained. Even when the whole mass is unloaded on to the ground, there is but little trouble maintaining a uniform mixture. In this way separate cars of coarse and fine material are not required, which is a matter of considerable importance in most cases on railroad work. The entire product of the crusher, in most cases at least, will be taken away at once, and is therefore generally a good arrangement for the operator of the plant.

The finest grade screened out to any extent at the crusher referred to was that which passed through a $\frac{3}{8}$-in. round mesh thick manganese steel screen. A sample of this taken from a car delivered on our work was screened with the following results:

Volume of Sample, as Taken from Top Layer in Car, 28.87 cu. in.

	Retained on a	No.	12	sieve,	17.14	cubic inches.
Remainder	,,	,,	20	,,	4.51	,,
,,	,,	,,	30	,,	3.16	,,
,,	,,	,,	50	,,	3.14	,,
,,	,,	,,	100	,,	4.06	,,
,,	passing through	No.	100	,,	2.71	,,

Of course the sum of the separate parts (34.72) exceeds the original 28.87. The experiment simply shows that there is a large portion of the fine material which is larger than ordinary sand grains, and also that there is only a small portion that is extremely fine.

With the kind of stone mixture just referred to we have specified 1 : 3 : 7½ concrete for abutment foundations, engine pit walls in roundhouses and machine foundations. A machine foundation which it was necessary to remove, in part, was found to be without voids and of great strength, at least so far as its ability to resist being removed was concerned. 1 : 2½ : 6 concrete is specified for abutment and similar work.

The amount of sand, 3 parts and 2½ parts, is made comparatively small, due to the proportion of fine material in the stone that is equivalent to sand, and due to the small proportion of voids in the stone resulting from the graded sizes of stone.

Aside from the matter of expense and ultimate strength, it would seem that the volume of sand to the barrel of cement should be kept as small as possible, consistent with making an easily spreading concrete, for work which is to be laid in forms, on account of the need of removing forms as soon as possible; a rich mortar setting, or at least gaining a given strength, much quicker than a lean mortar.

The suggestions in the paper of the evening will certainly aid in writing specifications which will enable the engineer to know beforehand what kind of concrete he will get and which will enable the contractor to estimate closely what the work will cost when he makes his proposal.

OBITUARY.

William Thomas Pierce.

MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

WILLIAM THOMAS PIERCE, who died at 12 Russell Avenue, Watertown, Mass., on February 26, 1906, was born November 12, 1854, at Leominster, Mass. He was one of four sons of John Q. A. and Elizabeth C. Pierce, the others being Charles Q., Henry B. and Myron E.

While still young, his parents moved from Leominster to Watertown, Mass., where he received his education in the public schools.

In 1871, before he was seventeen, he decided to adopt a professional life and entered the office of Ernest W. Bowditch, landscape gardener and engineer, as a student. From the first he was a close observer, a great reader, perhaps somewhat omnivorous in literary taste, and early began the excellent practice of indexing his professional reading.

In 1880, when the Mexican Central Railroad was starting construction, he obtained a position on the engineering force of that corporation, realizing that by going to Mexico he was not only enlarging his professional horizon but was taking advantage of an opportunity to broaden his general experience as well.

He liked railroad location and construction together with its free and outdoor life, but as he did not care about the sub-tropical climate of Mexico he retained his position only till 1882, going from there to Quebec, Canada, to engage on preliminary and location railroad surveys, staying there and in the immediate neighborhood till 1885, when he returned to Boston and reëntered Mr. Bowditch's office as a first assistant engineer.

At this time he took charge of the sewer systems at Bar Harbor, Waltham and Newburyport, during the building of which he developed many original and valuable methods for sewer construction work and in various ways proved fertile in resources.

In 1893, after starting in practice for himself, he was appointed superintendent of streets at Watertown, Mass., a position that he held until chosen chief engineer of the Metropolitan Park System in 1894, which post he held till obliged to withdraw on account of ill health in 1903; and even after that he continued his interest in the work of the office he had organized, until the end, in February, 1906.

Professionally it may be said of him that he was successful to a marked degree, that he was a good workman who knew how to use his tools to best advantage, and intolerant alike of slovenly or careless work in others.

Upright and honest in his dealings, methodical, persistent, conscientious and resourceful with his work, he was a man who not only had the entire confidence of his employers, but, what is quite as important and less common, the good-will of the laboring men and contractors with whom he came in contact.

That he showed himself a capable executive is proved by the effective organization he built up for the Metropolitan Park engineering office, where, amongst other matters, he was at all times trying to standardize the professional work to the end that all plans, notes and calculations could be easily and quickly referred to.

Though naturally quick and impulsive, his temper was well under control and he was quite as ready to laugh at a joke at his own expense as when some other person was the object; and many is the time when he poked fun at what he referred to as his own stupidity.

In August, 1903, he was practically obliged to withdraw from active work and ever after great care was exercised to avoid over-exertion and consequent valvular exhaustion of the heart, which from the first had been very distressing to him. Even when incapacitated from attending to any work he remained cheerful and uncomplaining. The end came February 26, 1906.

The deceased was a member of American Society of Civil Engineers, Boston Society of Civil Engineers, Middlesex Club, Boston Club, Boston Athletic Association.

In 1883 he married Almira P. Goss, of Salem, Mass., who, with one daughter, survives him.

Ernest W. Bowditch,
Daniel W. Pratt,
Committee.

Boston, Mass., May 26, 1906.

Casper Teiper.

Member of the Engineers' Society of Western New York.

On March 8, 1906, entered into rest at his home in the city of Buffalo, Casper Teiper, in the fifty-ninth year of his life.

Mr. Teiper, from the earliest portion of his career, was identified with the iron and steel business, most of the time being engaged in the manufacture of bridges and allied structures, and he witnessed and, indeed, had a prominent part in the development of that important part of the iron and steel industry from its infancy to the present day.

Mr. Teiper was a thorough bridge and structural engineer, his ability in this line being self-acquired, he never having had the advantages of a college education. His business connections for many years with the largest bridge company of Canada threw him into contact with the noted bridge engineers of the country, who placed in his care the fabrication and erection of most of the important bridges on the railroads of the Dominion.

Mr. Teiper was a many-sided man, being also expert in mechanical engineering, which enabled him to design and build successfully all kinds of heavy tools used in the fabrication of bridges. While engineer and superintendent of the Hamilton Bridge and Tool Works, this was a very important part of the business placed in his care. While at Hamilton he built the sheathing for the Port Huron tunnel, and also steel boats of various descriptions, among them being the *Chippewa*, which now plies between Lewiston and Toronto. Such achievements as these show the many-sided character of Mr. Teiper's mind and serve as monuments to the esteem in which his ability was held by men high up in engineering and business life.

Mr. Teiper was an indefatigable worker, never taking vacations, the only respite from business being in traveling on the trains from point to point where business took him. This extreme devotion to his work, however, was the cause of his physical decline, for he became afflicted with a creeping paralysis which nineteen years ago fastened itself upon him and, despite all efforts, gradually became more and more insidious and resulted finally in his death as above noted.

Mr. Teiper was born in Germany, November 13, 1846. Early in life he was brought to this country by his parents and settled in Detroit. When old enough to work, he located in New York City, where he was employed by a firm engaged in the building of marine engines. While there he spent his leisure time in the study of bridge engineering, taking an evening course at the Peter Cooper Institute. From August, 1871, to May, 1876, he was employed as draughtsman in the office of the Kellogg Bridge Company, of Buffalo, N. Y. From May, 1876,

to May, 1877, he was managing partner in the Vulcan Iron Works, of Bay City, Mich. From May, 1877, to September, 1879, he was employed as engineer and superintendent of the Hamilton Bridge Company, of Hamilton, Ont. From October, 1879, to September, 1880, he was engaged in the engineering department of the Keystone Bridge Company, of Pittsburg, Pa. From September, 1880, to April, 1892, he was engaged as engineer and manager of the Hamilton Bridge and Tool Company, of Hamilton, Ont. In April, 1892, he returned to this country and formed a partnership with Mr. Carl Meyer, they styling themselves the Buffalo Bridge and Iron Works. Here he acted as engineer. His disease at this time was severely taxing his strength and he decided to discontinue business, and in August, 1894, he sold his share of the business to Mr. Robert Wilson. He then took a trip abroad in an endeavor to regain his health, but with little result. He returned in the latter part of 1894, found that he could not remain idle and decided to go into business again. He bought a piece of land at Letchworth and Dark streets, Buffalo, and erected upon it the plant of the Buffalo Structural Steel Works, of which he was proprietor until its conversion in February, 1899, into the Buffalo Structural Steel Company, a corporation doing business under the laws of New York state. Mr. Teiper was president of this company from its formation until his death.

During the last four years of his life Mr. Teiper was physically absolutely helpless, yet his mind was alert and keen as ever. Even during this time he attended strictly to business, being to the office an example of unswerving regularity.

To them who knew him best Mr. Teiper presented a remarkable object lesson. His life taught one to be regular and precise in the performance of duty; to be cheerful in the presence of great bodily discomfort; to overcome the greatest obstacles in the attainment of laudable ambitions, and above all, to be honorable and honest in dealing with his fellowman, down to the minutest detail. His wife, Agnes M. Teiper, one daughter and three sons, survive him.

Dean Clyde Warren.

Member of the Boston Society of Civil Engineers.

Mr. Warren was the eldest of three brothers. He was born in the town of Stowe, Vt., May 31, 1874; attended the

district school near his father's farm; graduated from the Stowe High School, and took a college preparatory course of two years, 1890 and 1891, at the People's Academy, Morrisville, Vt.

It was his ambition to enter the Military Academy at West Point, and doubtless he could have won an appointment as he stood second in a class of over a hundred at the Morrisville Academy. His parents, however, did not wish him to go to West Point and as a compromise he was sent to the Scientific Military School, Norwich University, at Northfield, Vt. He entered in the class of 1896, but completed the course in three years, graduating in 1895 at the head of his class.

His first work after leaving college was upon some preliminary surveys for the Mt. Mansfield Electric Railroad, running from Waterbury to Stowe, Vt.

He was employed by the firm of French & Bryant, Brookline, Mass., a few months during the fall of 1895, and again in 1896 and 1899. His work with them consisted of surveys, the construction of roads, sewers and water works.

During the winter of 1895–96 he was connected with the City Engineer's Office, Somerville, Mass., and engaged in the general work of the office.

In the spring of 1896, together with a classmate, he went to Colorado and was for a time in the office of Davis & Byler, United States Deputy Mineral Surveyors, at Victor, in the Cripple Creek gold mining region. His work there consisted in running out claims and preparing plans and descriptions for United States patents.

The spring of 1896 saw the end of the "boom" in the Cripple Creek country and, as a consequence, a less demand for the services of engineers. Mr. Warren and his companion thought it the wisest plan to return East while they yet had the means rather than seek employment there under unfavorable conditions.

After working two months in the office of French & Bryant, at Brookline, Mass., he entered the office of the City Engineer of Cambridge, Mass., in July, 1896, and remained until November, 1898. He was engaged in Cambridge mostly on the survey and construction of the River Parkway, about four miles in length, along the north shore of the Charles. The work consisted of surveys and location, the supervision of construction of sea-walls and bulkheads, dredging and filling, the building of roadways and the creation of much agreeable landscape where there had been only salt marsh and mud flats.

During the winter of 1898–99 he was engaged as assistant engineer on the construction of the Rutland Canadian Railroad in Northern Vermont, on a section including the crossing of Lake Champlain at its northerly end.

Mr. Warren again worked in Brookline a short time in the spring of 1899. In June he entered the employ of the Metropolitan Sewerage Works, where, as assistant engineer, he was in charge of important construction work on the North Metropolitan system and on the High Level Sewer, including tunnel work and river crossings.

He was in the office of Olmsted Brothers, landscape architects, in 1904, and from June 1 to September 1, 1904, in the employ of the Massachusetts Highway Commission, most of the time in the Boston office, but for a short time as resident engineer of a section of road in Burlington, Mass.

On September 1, 1904, he took a position as assistant engineer on the rapid transit railroads of New York City, and was given immediate charge of the construction work in the New York heading of the tunnel under the East River from the Battery to Brooklyn.

He was employed constantly after leaving college, with the exception of a few weeks during the winter of 1898–99, but had never been absent from his work a day on account of sickness.

Mr. Warren had a weak heart, and early in March, 1905, when his physician forbade him to go again under air pressure, he felt that he was not doing his duty, and was annoyed greatly at not being able to go into the tunnel, though he kept on with the outside work.

The immediate cause of his death was due to blood poisoning, developing from a carbuncle. He left his office on Monday, July 3, complaining of a slight cold, but was out of doors again on Wednesday. The end came very suddenly and without warning and he passed away at midday, Thursday, July 6, 1905, in Brooklyn, N. Y. He was buried at Stowe, Vt.

Mr. Warren was married in Cambridge, Mass., September 27, 1900, to Maude Ella Mills, who survives him. He left no children.

He became a member of the Boston Society of Civil Engineers, March 18, 1903. All who came in contact with him professionally found him agreeable, energetic and capable; he had both patience and good judgment in an unusual degree, was conscientious and quiet in the performance of his duties

and commanded the confidence and esteem of those who were in any way associated with him. He made excellent use of his engineering training and was unusually careful and skillful in his work, which he did in a thorough and efficient manner. He was a constant reader of current engineering literature and accumulated a considerable engineering library. Of his future success as an engineer there was no doubt. He was a kind and loving husband, a loyal friend, always cheerful and ever ready to assist others in time of need.

J. Albert Holmes,
DeWitt C. Webb,
Committee.

ASSOCIATION OF ENGINEERING SOCIETIES.

ARTICLES OF ASSOCIATION ADOPTED DECEMBER 4, 1880.

FOR the purpose of securing the benefits of closer union and the advancement of mutual interests, the engineering societies and clubs hereunto subscribing have agreed to the following Articles of Association.

ARTICLE I.

NAME AND OBJECT.

The name of this Association shall be the "Association of Engineering Societies." Its primary object shall be to secure a joint publication of the papers and transactions of the participating societies.

ARTICLE II.

ORGANIZATION.

SECTION 1. The affairs of the Association shall be conducted by a Board of Managers under such rules and by-laws as they may determine, subject to the specific conditions of these articles. The Board shall consist of one representative from each society of one hundred members or less, with one additional representative from each additional one hundred members, or fraction thereof over fifty. The members of the Board shall be appointed as each society shall decide, and shall hold office until their successors are chosen.

SECT. 2. The officers of the Board shall be a Chairman and Secretary, the latter of whom may or may not be himself a member of the Board.

ARTICLE III.

DUTIES OF OFFICERS.

SECTION 1. The Chairman, in addition to his ordinary duties, shall countersign all bills and vouchers before payment and present an annual report of the transactions of the Board; which report, together with a synopsis of the other general transactions of the Board of interest to members, shall be published in the JOURNAL OF THE ASSOCIATION.

SECT. 2. The Secretary shall be the active business agent of the Board and shall be appointed and removed at its pleasure. He shall receive a compensation for his services to be fixed from time to time by a two-thirds vote. He shall receive and take care of all manuscript copy and prepare it for the press, and attend to the forwarding of proof-sheets and the proper printing and mailing of the publications. He shall have power, with the approval of any one member of the Board, to return manuscript to the author for correction if in bad condition, illegible or otherwise conspicuously deficient or unfit for publication. He shall certify to the correctness of all bills before transmitting them to the Chairman for countersignature. He shall receive all fees and moneys paid to the Association and hold the same under such rules as the Board shall prescribe.

ARTICLE IV.

PUBLICATIONS.

SECTION 1. Each society shall decide for itself what papers and transactions of its own it desires to have published and shall forward the same to the Secretary.

SECT. 2. Each society shall notify the Secretary of the minimum number of copies of the joint publications which it desires to receive, and shall furnish a mailing-list for the same from time to time. Copies ordered by any society may be used as it shall see fit. Payments by each society shall, in general, be in proportion to the number of copies ordered, subject to such modification of the same as the Board of Managers may decide by a two-thirds vote to be more equitable. Assessments shall be quarterly in advance, or otherwise, as directed by the Board.

SECT. 3. The publications of the Association shall be open to public subscription and sale, and advertisements of an appropriate character shall be received under regulations to be fixed by the Board.

SECT. 4. The Board shall have authority to print with the joint publications such abstracts and translations from scientific and professional journals and society transactions as may be deemed of general interest and value.

ARTICLE V.

CONDITIONS OF PARTICIPATION.

SECTION 1. Any society of engineers may become a member of this Association by a majority vote of the Board of Managers, upon payment to the Secretary of an entrance fee of fifty cents for each active member, and certifying that these Articles of Association have been duly accepted by it. Other technical organizations may be admitted by a two-thirds vote of the Board, and payment and subscription as above.

SECT. 2. Any society may withdraw from this Association at the end of any fiscal year by giving three months' notice of such intention, and shall then be entitled to its fair porportion of any surplus in the treasury, or be responsible for its fair proportion of any deficit.

SECT. 3. Any society may, at the pleasure of the Board, be excluded from this Association for non-payment of dues after thirty days' notice from the Secretary that such payment is due.

ARTICLE VI.

AMENDMENTS.

These articles may be amended by a majority vote of the Board of Managers, and subsequent approval by two thirds of the participating societies.

ARTICLE VII.

TIME OF GOING INTO EFFECT.

These articles shall go into effect whenever they shall have been ratified by three societies, and members of the Board of Managers appointed. The Board shall then proceed to organize, and the entrance fee of fifty cents per member shall then become payable.

RULES OF THE BOARD OF MANAGERS OF THE ASSOCIATION OF ENGINEERING SOCIETIES, ADOPTED MARCH 1, 1905.

SOCIETIES.

Assessments.

1. Assessment bills shall be rendered to the societies quarterly after the mailing of the Journals for March, June, September and December.

2. Each society shall be assessed in proportion to the number of names upon its mailing list at the time when the assessment is made.

3. Each society shall be entitled to receive, gratis, five copies of each issue of the Journal for each of its representatives on the Board of Managers of the Association.

Delinquent Societies.

4. Any society which shall remain indebted to the Association for a sum exceeding two dollars per member for more than ninety days after mailing of notice by the Secretary, shall be suspended from the privileges of the Association until the cause be removed, provided that this rule shall not apply to indebtedness on account of advertisements secured by the society for the Journal.

Government.

5. A meeting of the Board of Managers may be called by the Chairman at any time, and shall be called by the Chairman or Secretary upon the written request of any three members of the Board, and such call shall give not less than three weeks' notice of said meeting.

6. At any meeting of the Board of Managers, duly called as provided in Rule 5, one fourth of the whole number of members (including the Chairman) shall constitute a quorum, provided that not less than three of the constituent societies be represented at such meeting.

7. Motions for letter ballot shall be made and seconded and then forwarded by the Chairman to each member of the Board for discussion.

8. All letter ballots shall close four weeks after the date of mailing call, by the Chairman, for vote.

9. Rules of the Board of Managers may be amended at any time by a majority vote of the Board, as ascertained by letter ballot.

Officers.

10. The term of office of the Chairman and that of the Secretary shall be two (2) years, and shall begin on January 1 of the even years, but they shall remain in office till their successors are chosen.

11. The election of officers shall occur at any time at a called meeting of the Board, or by letter ballot between October 1 and December 1 of the odd years.

12. If the election is by letter ballot, the Chairman shall, through the Secretary, give notice of such election prior to October 10 of each odd year, and shall also give notice, at the same time, of the appointment of two tellers in one city, members but not officers of the Board, to whom

the votes shall be mailed. These tellers shall open the ballots on November 1, and report the result to the Chairman of the Board. If no one has received a majority of the votes cast for either office, the Chairman shall order a new ballot, similar to the first, but limiting the names voted for to the two receiving the highest numbers of votes for that office on the first ballot. The tellers shall open the second ballot on December 1, and report as before. The Chairman shall then announce the result of the ballot to all the members, and the new officers shall act from the beginning of the following calendar year. In the event of the second ballot resulting in a tie, the Chairman shall select between the two candidates by lot.

13. Vacancies in the offices of the Board may be filled at any time, either by a meeting of the Board or by letter ballot. In case of a vacancy occurring, the remaining officer shall discharge the duties of both till the vacancy is duly filled.

14. The Secretary shall receive a salary of nine hundred dollars ($900) per annum.

ACCOUNTS.

Audit.

15. Prior to the close of each odd year, the Chairman shall appoint from the members of the Board of Managers, two auditors to examine and report upon the accounts of the Secretary.

JOURNAL.

Contents.

16. The matter published in the Journal shall be restricted to:

(*A*) *Monthly.*

1. Papers submitted by the societies for publication, including presidential addresses and memoirs of deceased members.
2. Proceedings of meetings of the societies.
3. Lists of officers of the societies.
4. List of members of Board of Managers.
5. Advertisements.

(*B*) *Annually.*

1. Annual report of Chairman and of Secretary of Board of Managers.
2. Articles of Association, Rules of Board and rulings of Chairman.

(*C*) *Biennially.*

Report of Auditors.

Conduct.

17. Arrangements with printers and illustrators shall be made by the Secretary, subject to the approval of the Board of Managers.

18. The arrangement of matter, the selection and manner of reproducing illustrations and all other matters relating to typography, shall be decided by the Secretary with the approval of the Chairman.

19. The Secretary shall insert in each issue of the Journal the following: Editors reprinting articles from this Journal are requested to credit the author, the Journal of the Association and the society before which such articles were read.

20. Authors of papers appearing in the JOURNAL shall have appended to their names only the words, " Member of................Society."

REPRINTS.

21. Reprints of papers appearing in the JOURNAL shall be made, when requested, for the account of the societies submitting the papers for publication.

22. Each author shall be entitled to receive gratis 50 reprints of his paper, with its discussion and illustrations, on condition that application for such reprints is made by the author, through the secretary of the society presenting the paper for publication, previous to the printing of the paper for the JOURNAL.

23. The rates of charges to the societies for other reprints shall be adjusted by the Chairman and Secretary.

ILLUSTRATIONS.

24. Cuts, published with linear scales, shall bear metric scales, unless objection is made by the authors.

ADVERTISEMENTS.

25. The procuring and selection of advertisements, including the fixing of rate of commissions, shall be subject to the control of the Chairman and Secretary.

26. Advertisements procured for the JOURNAL by the societies composing the Association shall be charged to those societies, less 90 per cent commission.

SUBSCRIPTIONS.

27. The rate of subscription to the JOURNAL shall be $3.00 per annum.

28. Dealers shall be allowed on subscriptions a discount of 50 cents per annum.

29. Educational and charitable institutions may be furnished with the JOURNAL at $1.50 per annum, subject to the approval of the Chairman and Secretary.

EXCHANGES.

30. Exchanges with other periodicals may be made subject to the approval of the Chairman and Secretary.

SALES AND GRATIS COPIES.

31. The price of single copies of the JOURNAL shall be 30 cents, less a discount of 5 cents to dealers.

32. Members of the societies belonging to the Association shall be entitled to receive copies of the JOURNAL at 20 cents each. This rule is subject to amendment by the Chairman and Secretary in the case of scarce or surplus numbers, or of sets of back numbers.

33. The Secretary is authorized to furnish to the author of any paper to whom reprints are not given, and to each of those taking prominent part in the discussion, five gratis copies of the JOURNAL containing such paper, and, at 15 cents each, additional copies of the issue of the JOURNAL containing such paper, provided due notice be given in advance, stating the number of such extra copies wanted.

FINAL CONTROL BY BOARD.

34. The exercise of any discretions herein delegated to the Chairman and Secretary shall be subject to the final control of the Board of Managers.

ANNUAL REPORT OF THE CHAIRMAN OF THE BOARD OF MANAGERS.

BOSTON, June 23, 1906.

Gentlemen,— In presenting my report for the year ending December 31, 1905, with the report of the Secretary, I desire to thank the members of the Board for the confidence expressed and honor conferred by my reëlection as your chairman for a further term.

The interesting facts regarding the publication of the JOURNAL, which is the primary purpose of the Association, are fully stated in detail in the Secretary's report.

The number of societies belonging to the Association remains the same as in 1904, with a net increase in membership, as shown by the mailing list of the JOURNAL, of 76. The net assets of the Association remain substantially the same as at the close of the previous year.

Although the aggregate membership of the several societies is more than 50 per cent. greater than in 1894, the number of pages of papers published during the past year was 16 per cent. less than in the earlier year. This may indicate that times are so prosperous that the members of the engineering profession have little time to devote to literary work, but the result is to be deplored, and it is hoped that a different statement can be made at the close of the coming year.

The reduction in the number of papers presented for publication, and the fact that the number of illustrations required was also smaller, made possible a material reduction in the cost of the JOURNAL. There has, however, been so large an increase in the cost of printing during the past two years that the annual assessment for the JOURNAL is not likely to fall below $2.50 per annum.

Several important matters have been considered by the Board during the year, although no meeting was held, the business having all been conducted by correspondence.

The question of codifying and revising the rules of the Board, which had been under consideration during the greater part of the year 1904, was finally decided on March 1 by the adoption of the rules appended to this report.

The position of secretary, made vacant by the resignation of Mr. John C. Trautwine, Jr., who for many years had so ably

managed the business affairs of the Association, was filled in March by the election of Frederick Brooks, of Boston. Mr. Trautwine's resignation was presented to take effect on December 31, 1904, but he very kindly took charge of the publication of the first three numbers of the JOURNAL, and in April the publication office was removed from Philadelphia to Boston.

In closing, I ask for the same hearty coöperation which has been given during the past two years, in order that the Association may continue to grow and be of increased value to the engineering profession.

Respectfully submitted,

DEXTER BRACKETT,
Chairman.

ANNUAL REPORT OF THE SECRETARY OF THE BOARD OF MANAGERS.

31 Milk Street, Boston, June, 1906.

Dexter Brackett, Chairman Board of Managers:

Dear Sir, — I submit as the chief feature of the report of the Secretary for the year 1905, during the greater part of which I was Secretary, the following nine statements in tabular form, A to J, corresponding to the forms used in the 1904 report of my predecessor. I add a few comments with regard to changes during the year, etc.

The expense for postage has been increased by the transfer of the place of publication to Boston, inasmuch as the regulations of the Post Office Department require payment at the rate of a cent for two ounces upon Journals delivered by carrier within the postal district where the Journal is published. This includes a very large number in the case of the Boston Postal District, but included only a small number in the case of the Philadelphia Postal District. The Journals going outside of the postal district where they are published have the benefit of the pound rate as second-class matter. This has made a difference estimated at about seven dollars per month in the expense of mailing the Journal.

The theory of the publication of the Journal appears to have been that it was a record, or minutes of proceedings, for a month, and was to be published during the following month. This practice, being at variance with the common custom of publishing periodicals as early as the date which they bear, has caused annoyance in several ways; and it is thought preferable to have the Journal of any month published in that month. The present Secretary has fallen considerably behind even the above-mentioned theoretical program. Nevertheless, he intends to bring the publication up to date in accordance with the usual custom.

Exchanges are considered important because of their affording to other periodicals the opportunity of giving credit to the Journal among their readers. On the other hand, those other periodicals when sent to the Secretary have not been put to the corresponding use, as the Journal publishes nothing from other periodicals. Instead of having them sent to the Secretary of the Association, it appeared better to have the other periodicals sent directly to such of the societies as desired them. Though this was not fully carried out until after the expiration of the year 1905, the result is that a list of the exchanges was sent to the secretaries of the local societies accompanied by a letter asking what price each Society would be willing to pay to the Association for any desired periodicals, also what periodicals it would like to receive if it did not have to pay for them. After comparing the few replies that were received, a few of the periodicals were assigned to the highest bidders; and a great many for which no offers to pay had been made were assigned to societies which expressed willingness to receive them gratis. These periodicals have accordingly been requested to change their address from the office of the Secretary of the Association to that of a local society, and they have in many cases complied with this request. The remaining periodicals upon

our exchange list have generally been notified that we do not have use for copies from them although we shall be pleased to continue sending them the JOURNAL.

Incidentally to the removal of the place of publication of the JOURNAL a great reduction has been made of the stock on hand of back numbers of the JOURNAL. It was stated in the Secretary's report for 1904 that about 43 000 numbers were on hand. There are scarcely any copies sold of JOURNALS more than five or six years old, though there is a considerable sale of recent numbers to supply lost copies, etc. Accordingly, a large amount of the accumulated stock was sold as old paper, and there was removed to Boston only a limited number of copies of each number of the JOURNALS of past years (about 12 000 in all), so that the expense for transportation and storage was not nearly as great as would have been involved in an attempt to remove the whole 43 000.

Respectfully yours,

FRED. BROOKS.

APPENDIX A.

STATEMENT OF RECEIPTS AND EXPENDITURES DURING 1905.

CASH, 1905.

Dr.

To Cash Balance, January 1, 1905	$457.93
,, Engineers' Club of St. Louis	648.44
,, Civil Engineers' Club of Cleveland	766.98
,, Boston Society of Civil Engineers	1 550.44
,, Engineers' Club of Minneapolis	85.41
,, Civil Engineers' Society of St. Paul	53.01
,, Montana Society of Engineers	331.50
,, Technical Society of the Pacific Coast	644.77
,, Detroit Engineering Society	568.62
,, Engineers' Society of Western New York	142.50
,, Louisiana Engineering Society	285.64
,, Toledo Society of Engineers	174.78
,, Subscriptions	749.57
,, Advertisements	201.00
,, Sales of JOURNAL	111.90
,, ,, ,, Reprints	2.50
,, ,, ,, Descriptive Index	22.50
,, ,, ,, Sundries	32.75
,, Interest on deposits	26.64
	$6 856.88

Cr.

By Printing	$3 954.97
,, Illustrations	415.64
,, Secretary's salary	250.00
,, Journal index	51.00
,, Stationery	36.89
,, Postage	384.30
,, Telegrams and) telephone)	42.94
,, Express charges	3.20
,, Sundry expenses	75.23
,, Cash balance, December 31, 1905	1 642.71
	$6 856.88

APPENDIX B.

Expenses and Earnings for 1905.
("Profit and Loss.")

EXPENSES.

Printing and binding	$2 416.58	
Illustrations	1 060.14	
Mailing	334.82	
Secretary's salary	250.00	
Advertising expenses	1.00	
Journal Index	51.00	
Stationery	87.39	
Postage	45.74	
Telegrams (and telephone)	42.94	
Express charges	5.55	
Sundry expenses (some packing and storing Journals)	148.12	
Commission on subscriptions	38.65	
" " society advertisements	539.70	
" " sales of Journal	3.90	
Sales of reprints	168.86	
		$5 194.39

EARNINGS.

Excess payment by Engineers' Club of St. Louis on second assessment	$0.02	
Assessments	4 271.27	
Subscriptions	673.70	
Association advertisements	82.00	
Society advertisements	599.67	
Sales of Journals	111.53	
" " Descriptive Index	17.50	
" " exchanges	9.25	
" " sundries	8.50	
Interest	26.64	
		5 800.08
Excess of earnings over expenses		$605.69

Accounts with Societies include, besides their subscriptions to Journal, some charges for advertisements, reprints, exchanges, etc. Printers' bills include, besides the Journal, some charges for reprints, illustrations, stationery, freight, etc. The figures for the minor items of Receipts and Expenditures and Assets and Liabilities vary accordingly from those of Expenses and Earnings. The item of mailing Journal consists largely of postage.

APPENDIX C.

Balance Sheet, December 31, 1905.

ASSETS.

Cash		$1 642.71	
Receivable from Societies:			
Engineers' Club of St. Louis	$133.08		
Civil Engineers' Club of Cleveland	7.00		
Boston Society of Civil Engineers	34.90		
Engineers' Club of Minneapolis	302.38		
Montana Society of Engineers	66.25		
Technical Society Pacific Coast	1.50		
Engineers' Society Western N. Y.	67.50		
		612.61	
Subscribers		98.63	
Purchasers of Journal		9.50	
Advertisers		101.66	
Furnishers (deposited with Postmaster)		4.80	
Stock of Journal*	$390.80		
Stock of Descriptive Index	175.00		
		565.80	
			$3 035.71

LIABILITIES.

Secretary's salary, eight months	$600.00	
Printers	146.87	
		746.87
Net assets, December 30, 1905		$2 288.84

* Figures of Stock of Journal differ from what was given for the previous year only by the sum for which part was sold as old paper, it being assumed that any other decrease and increase balanced each other. There was decrease by other sales of old copies and increase by the printing of surplus copies of the 1905 Journals.

APPENDIX D.

Detailed Statement of Gross Cost of Journal during 1905, by Months.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	Composition.	Paper, Presswork and Binding.	Wrapping, etc.	Postage.	Sum of 1,2,3 and 4.	Illustrations.	Manufacture. Sum of 1, 2 and 6.	Wrappers.	Sec'y's Salary.	Sundrics.	Sum of 5,6,8 and 9.	No. of Pages.†	Total Gross Cost per Page.‡	No. of Copies Printed.
January....	$96.69	$107.72	$7.02	$10.34	$221.77	$47.65	$252.06	$4.75	$50.00	$19.07	$324.17	64	$5.07	2 500
February...	84.42	151.05	6.15	12.34	253.96	214.93	450.40	4.75	50.00	19.07	523.64	72	7.27	2 500
March......	172.70	220.22	7.77	19.16	419.85	178.53	571.45	4.75	75.00	19.07	678.13	138	4.91	2 500
April.......	177.38	127.05	46.20	12.34	362.97	3.70	308.13	*	75.00	19.07	441.67	104	4.25	2 500
May........	81.10	99.40	12.46	21.67	214.63	354.53	535.03		75.00	19.07	644.16	78	7.31	2 500
June.......	131.40	138.60	10.42	20.31	300.73	123.30	393.30		75.00	19.07	499.03	112	4.46	2 500
July........	91.15	99.00	9.67	16.82	216.64	38.90	229.05		75.00	19.07	330.54	82	4.06	2 450
August.....	45.85	71.15	11.03	15.03	143.06	9.10	126.10		75.00	19.07	227.16	54	4.34	2 500
September..	54.53	71.15	9.81	14.71	150.20	22.79	148.47		75.00	19.07	247.99	54	4.59	2 500
October.....	29.95	59.40	8.98	14.21	112.54	50.04	139.39		75.00	19.07	237.58	42	5.66	2 500
November..	44.00	71.15	9.63	14.57	139.35	2.46	117.61		75.00	19.07	216.81	54	4.25	2 500
December...	105.06	95.45	9.74	16.48	226.73		201.51		75.00	19.08	301.73	72	4.51	2 500
	$1 114.23	$1 311.34	$148.88	$187.98	$2 762.43	$1 045.93	$3 472.50	$14.25	$850.00	$228.85	$4 672.61	926	$5.06	29 950

* In subsequent numbers wrappers were included in printers' charge.
† Plus covers.
‡ Exclusive of sundries.

APPENDIX E.

Net Cost of Journal, 1905.

Gross cost, as per Appendix D			$4 672.61
Add cost of reprints		$309.85	
Less sales of reprints		140.99	
			168.86
			$4 841.47
Deduct earnings, as per Appendix B:			
From subscriptions	$673.70		
Less commissions	38.65		
		$635.05	
From sales of Journal	$111.53		
Less commissions	3.90		
		107.63	
From sales of Descriptive Index		17.50	
,, ,, ,, exchanges		9.25	
,, ,, ,, sundries		8.50	
,, Association advertisements		82.00	
,, society advertisements	$599.67		
Less commissions	539.70		
		59.97	
From interest on deposits		26.64	
			946.54
Net cost of Journal, 1905			$3 894.93
Net cost per 100 copies, 1905			$13.00
,, ,, ,, ,, ,, 1904			17.72
Decrease, 1905, 26.6 per cent			$4.72

APPENDIX F.

[Statement of Material in Journal during 1905, by pages

	Papers.	Pro-ceed-ings.	Chair-man's Report, etc.	Adver-tise-ments.	Indexes to Vols.	Totals.	Cuts.	Plates and Full-Page Cuts.
January	16	9	16	18	0	59	8	2
February	41	8	0	18	0	67	21	9
March	83	31	0	18	0	132	12	18
April	66	16	0	18	0	100	13	0
May	55	1	0	18	0	74	12	22
June	81	1	0	18	7	107	22	2
July	60	0	0	18	0	78	10	6
August	29	5	0	18	0	52	12	0
September	27	7	0	18	0	52	0	1
October	21	1	0	18	0	40	2	5
November	30	3	0	19	0	52	0	1
December	43	3	0	18	5	69	0	1
	552	85	16	217	12	882	112	67
Covers						48		
Total						930		

APPENDIX G.

Comparison of the mailing lists of the JOURNAL at the close of 1904 and 1905 respectively:

	1904.	1905.	Increase.	Decrease.
Engineers' Club of St. Louis	209	209		
Civil Engineers' Club of Cleveland	216	254	38	
Boston Society of Civil Engineers	595	614	19	
Engineers' Club of Minneapolis	98	99	1	
Civil Engineers' Society St. Paul	21	23	2	
Montana Society of Engineers	102	92		10
Technical Society of the Pacific Coast	171	169		2
Detroit Engineering Society	139	167	28	
Engineers' Society of Western New York	51	52	1	
Louisiana Engineering Society	70	67		3
Toledo Society of Engineers	71	71		
In the societies of the Association	1 743	1 817	89	15
Net increase 74				
Extra copies to societies	56	95	39	
Advertisers	31	23		8
Exchanges	141	131		10
Subscribers	232	236	4	
Complimentary copies	1	2	1	
	2 204	2 304	133	33

APPENDIX H.

Comparison of Conditions, 1894 to 1905, Inclusive.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
							Pages of Papers.		Gross Cost of Journal.*					Illustrations.			
Year.	Number of Societies in Association, Dec 31.	Number of Names on Mail Lists of Societies, Dec. 31.	Subscribers, Dec. 31.	Exchanges, Dec. 31.	Net Earnings from Advertisements.	Total Number of Pages in Journal.	Total.	Per 1 000 Members on Mail List.	Total.	Per Page.	Per Member.	Per Member per 1 000 Pages.	Annual Assessment per Member.	Small Cuts.	Plates and Full-Page Cuts.	Cost. Appendix B.	Net Assets, Dec. 31. Appendix C.
1894	8	1 174	176	110	$671.00	1 290	653	556	$5 775.59	$4.48	$4.92	$3.81	$3.00	86	54	$651.60	—$758.91†
1895	11	1 477	215	122	599.09	1 482	792	536	5 911.48	3.99	4.00	2.70	3.66	116	66	859.60	223.93
1896	9	1 106	241	108	763.25	856	490	443	3 928.42	4.59	3.55	4.15	3.00	62	56	771.39	1 244.94
1897	10	1 252	233	102	410.25	1 016	638	510	3 140.43	3.09	2.51	2.47	2.50	57	45	503.85	2 562.04
1898	12	1 370	246	114	465.58	1 110	738	539	3 462.08	3.12	2.53	2.28	2.00	166	42	729.38	2 936.71
1899	11	1 475	249	115	390.88	958	544	369	3 233.44	3.38	2.19	2.29	2.00‡	124	30	561.24	2 442.70‡
1900	11	1 541	216	116	370.83	1 130	666	432	4 351.53	3.85	2.82	2.50	2.00	112	27	590.82	2 162.67
1901	11	1 597	224	115	244.10	1 074	646	405	4 856.64	4.52	3.04	2.83	2.00	213	55	1 160.90	2 062.72
1902	11	1 544	220	135	260.60	1 030	610	395	3 927.01	3.81	2.54	2.36	2.00	172	20	442.43	2 601.19
1903	10	1 588	222	131	108.80	1 006	568	358	4 133.24	4.11	2.60	2.58	2.00	78	63	773.47	2 476.54
1904	11	1 743	232	141	211.58	1 189	681	391	6 163.44	5.18	3.54	2.98	2.50	178	84	1 701.18	2 300.65
1905	11	1 817	236	131	141.97	930	552	304	4 672.61	5.02	2.57	2.76	2.37½	112	67	1 060.14	2 906.34

* The publication of the Descriptive Index of Current Technical Literature was discontinued at the end of 1895.

† Deficit at close of 1894. Since then, each year has shown a surplus.

‡ During 1899, with an assessment of $2.00 per member, the Association made a rebate of $1.00 per member for the purpose of reducing surplus, making the actual charge only $1.00 per member, and reducing the assessment by about $1 400.

APPENDIX J.

Comparison of Conditions, 1903, 1904, 1905.

	1	2	3	4	5	6				7				8
						Gross Cost of Journal.				Net Cost of Journal.				
						a	b	c	d	a	b	c	d	
December 31.	Members on Mail List.	Total Pages in Journal.	Printers' Bills for Journal.	Cost of Illustrations.*	Cost of Manufacture.	Total.	Per Page.	Per Member.	Per Member per 1 000 Pages.	Total.	Per Page.	Per Member.	Per Member per 1 000 Pages.	Net Assets.
	App. H, Col. 2.	App. H, Col. 6.	App. D, Col. 5.	App. H.	App. D, Col. 7.	App. H, Col. 9.	App. H, Col. 10.	App. H, Col. 11.	App. H, Col. 12.	App. E.				App. G, Col. 17.
1903.....	1 588	1 006	$2 543.45	$773.47	$3 134.80	$4 133.24	$4.11	$2.60	$2.58	$3 245.58	$3.23	$2.04	$2.00	$2 476.54†
Increase..	155	183	1 770.40	221.99	1 871.14	2 030.20	1.03	0.94	0.40	1 813.68	1.03	0.86	0.44	....
Decrease..	....	....	....	....	....	....	....	....	....	....	....	....	....	175.89†
Per Cent..	9.8	18.2	69.6	28.7	59.7	49.1	25.1	36.2	15.5	55.9	31.9	42.2	22.0	7.1†
1904.....	1 743	1 189	$4 313.85	$995.46	$5 005.94	$6 163.44	$5.14	$3.54	$2.98	$5 059.26	$4.26	$2.90	$2.44	$2 300.65†
Increase..	74	....	....	....	....	....	....	....	....	....	....	....	....	605.69
Decrease..	....	259	1 551.42	569.57	1 535.44	1 490.83	0.12	0.97	0.22	1 164.33	0.08	0.76	0.41	....
Per Cent..	4.2	21.7	36.0	57.2	30.6	24.18	2.3	27.4	7.38	23.0	1.87	26.2	16.8	26.3
1905.....	1 817	930	$2 762.43	$425.89	$3 472.50	$4 672.61	$5.02	$2.57	$2.76	$3 894.93	$4.18	$2.14	$2.03	$2 906.34

* Exclusive of printers' bills for paper and presswork on cuts, and inserting.

† The decrease in net assets, during 1904, is here made to appear much less than it is in fact, by the counting, as assets at close of 1904. of the Association's stock of Descriptive Index, $192.50, and of the Journal, estimated at $430.00, neither of which has hitherto been included, and by the omission of the cost ($241.34) of the December Journal from the statement of liabilities. Omitting the stocks of Journal and of Index from the assets, and including the cost of the December Journal with the liabilities, as heretofore, we should have: net assets, December 31, 1904, $1 436.81; decrease, $1 039.73. Per cent, 42.0.

MEETING OF BOARD OF MANAGERS AT FRONTENAC, N. Y., JUNE 28, 1906.

PRESENT: Dexter Brackett, H. C. Toensfeldt, John R. Freeman, Gardner S. Williams, William A. Haven, also Fred. Brooks, Secretary; also, by invitation, John C. Trautwine, Jr., former secretary of the Board.

The action of the Chairman in inviting Mr. Trautwine to be present at the meeting was approved by unanimous vote. After discussion by the gentlemen present, and the reading of letters from A. P. Greensfelder, S. E. Tinkham, Dwight Porter, Charles W. Sherman, George W. Dickie, W. B. Wright and others, the following votes were passed, there being in each case five votes in the affirmative and none in the negative.

With regard to the question of allowing societies to subscribe for a number of JOURNALS less than the number of their members it was

Voted, That Section 2 of the Rules of the Board of Managers be amended by adding the words, " provided, that no society shall be assessed for less than twenty (20) copies of the JOURNAL, and provided, that no society shall be assessed for less than fifty (50) per centum of its membership at the time when the assessment is made."

In case this proposed amendment shall be made by letter ballot, under Section 2 of Article IV of the Articles of Association, Section 2 of the Rules of the Board will read as follows:

" 2. Each society shall be assessed in proportion to the number of names upon its mailing list at the time when the assessment is made, provided, that no society shall be assessed for less than twenty (20) copies of the JOURNAL, and provided, that no society shall be assessed for less than fifty (50) per centum of its membership at the time when the assessment is made."

With regard to inviting general discussion of papers it was

Voted, That the Secretary invite discussions on papers published in the JOURNAL, from all members of the associated societies and others, and that such discussions be collected, edited, and published by him in accordance with the rules governing the publication of papers in the JOURNAL, and such further rules as he may establish with the approval of the Board of Managers.

With regard to the suggestion of changing the JOURNAL to a quarterly publication, it was

Voted, That it is the sense of this meeting that a change of the JOURNAL from a monthly to a quarterly publication would be a step backward.

With a view to making known the advantages which societies may gain by joining the Association, it was

Voted, That the Chairman and Secretary be authorized and instructed to draft from time to time statements of the purposes of the Association, for publication in the JOURNAL.

Adjourned.

FRED. BROOKS, *Secretary*.

ASSOCIATION OF ENGINEERING SOCIETIES.

Organized 1881.

VOL. XXXVI. MAY, 1906. No. 5

REINFORCED CONCRETE CASING FOR THE PROTECTION OF PILES IN WHARF CONSTRUCTION.

BY F. A. KOETITZ, MEMBER OF THE TECHNICAL SOCIETY OF THE PACIFIC COAST.

[Read before the Society, April 6, 1906.]

DURING the many years of my experience in construction work I have often wondered why some good practical means for the effective protection of wooden piling against the ravages of marine life and even against general deterioration had not been found, and from time to time I have investigated many so-called "pile protections," always to find them wanting in one or another necessary essential. After giving this matter considerable study I have finally designed a system that I am certain will prove effective as a protection, which, being relatively cheap, can be used in many instances without any wooden piling, and it is the object of this paper to bring this system before the members of this Association.

The main feature of this construction is a reinforced concrete casing of practical length, or sections of such casing joined together, and with them either to encase wooden piles or to replace them entirely. When properly placed, in any of the ways in which these casings would be applicable, they are then to be filled with concrete and are ready to receive the superstructure.

The casings may be made of almost any desired diameter and with any preferred reinforcement, and for those of 18 in. to 24 in. diameter the shell need not be over $1\frac{1}{4}$ in. thick, larger diameters to be proportionately thicker, and the casings are, therefore, easily handled.

Fig. 2.

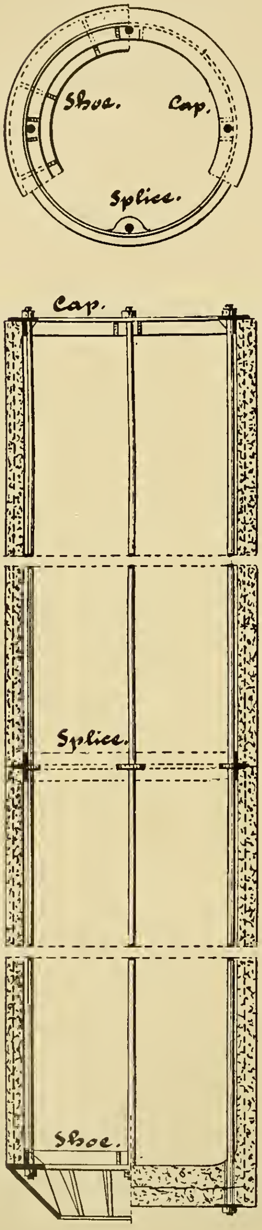


Fig. 1.

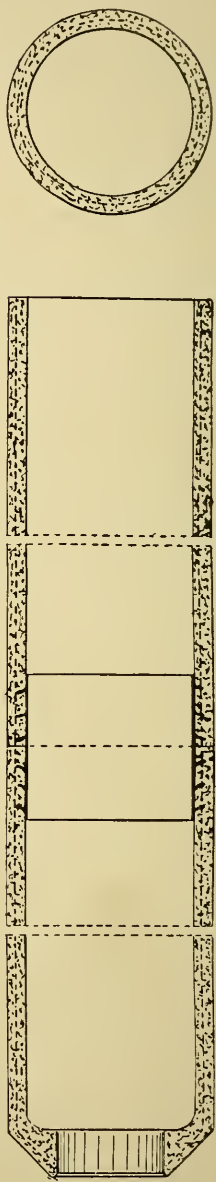


Fig. 1 shows two such sections of the casings joined by a simple sleeve that is inserted and properly connected at the place of manufacture. This connection is designed for light work only, such as protecting piles or certain portions thereof, or for repairing old piles. The bottom forms a shoe and at the same time serves as a guide in sinking the casing over the pile.

Fig. 2 shows a casing for heavier work, to be used more in the nature of a cylinder, with various sections joined together

Fig. 4.

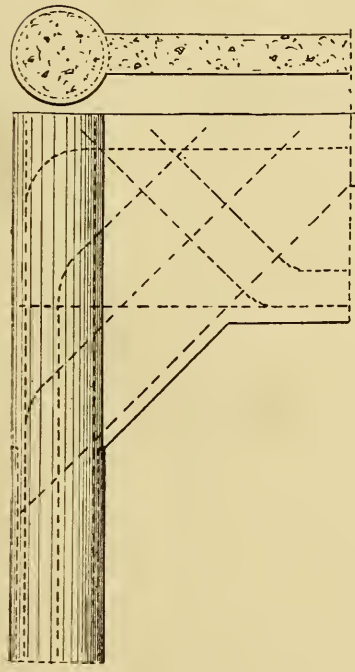
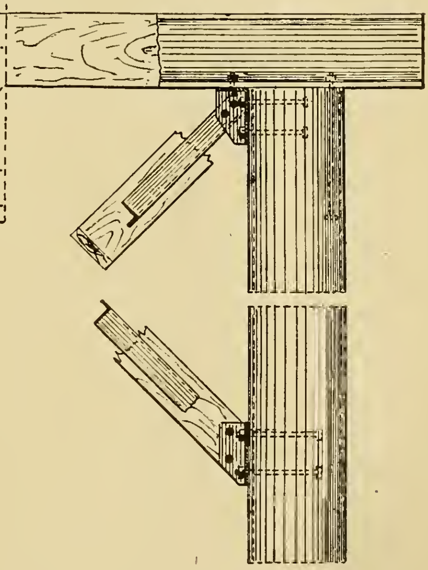


Fig. 3.



by proper cap, splices and shoe of metal, and the desired number of longitudinal rods. The shoe, if preferred, may be made of concrete similar to that in Fig. 1. In this case, the sections are assembled at the site of the work, as needed; they are supported, while being sunk in place, by rods, and when placed these rods are embedded in the concrete filling and form an additional reinforcing of the concrete and an absolute bond of the joints.

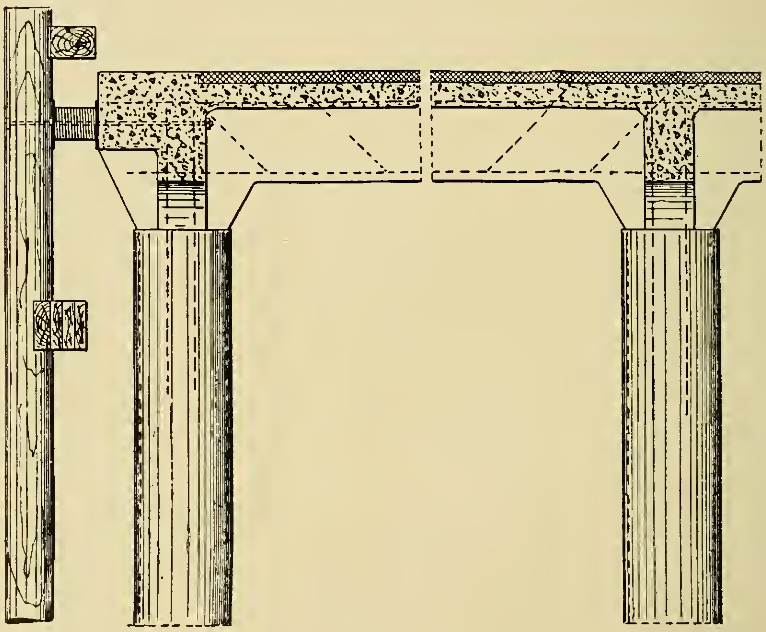
Fig. 3 shows these casings in the construction of trestle bents or piers, with cap of wood or steel, anchored to the interior

concrete, also with wood or steel bracing, attached in an approved substantial manner.

Fig. 4 shows the use of casings in conjunction with a reinforced concrete top work for piers or trestle where the head room is small and only a shallow bracing can be used. This combines the bracing and main girder all in one and will be found very rigid and durable.

Fig. 5 shows the use of the casings in the construction of wharves where they are admirably adapted to carry a reinforced

Fig. 5.



concrete floor construction. Such a wharf would be almost indestructible, requiring practically no repairs, and would be entirely fireproof. It should be obvious to any builder, that such a wharf must be a better investment than a wooden one under almost any condition. Where this wharf is used for docking vessels, it should be surrounded, of course, with the usual spring lines of wooden piling.

While the upper parts of these casings are suitable for any style of superstructure, the lower parts can be constructed and adapted to fit almost any kind of foundation.

Fig. 6 shows, perhaps, the most common requirements. This consists of driving a pile to its proper bearing capacity, of cutting off the pile, thus driven, at the desired level (or of cutting off an old pile at such level), of sinking the casing over the pile to the required depth for the protection of the pile, of pumping out the casing and of filling the interior with concrete. The lower shoe, as shown, forms a guide to keep the casing always at a certain distance from the pile, so as to assure at least a certain fixed thickness of concrete between the pile and the casing. The conical shape of the shoe tends to throw the soil or mud away from the pile and will allow only a minimum amount

Fig. 6.

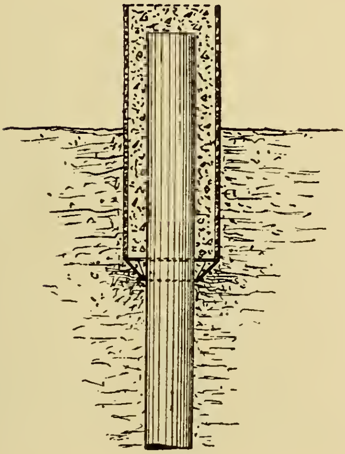
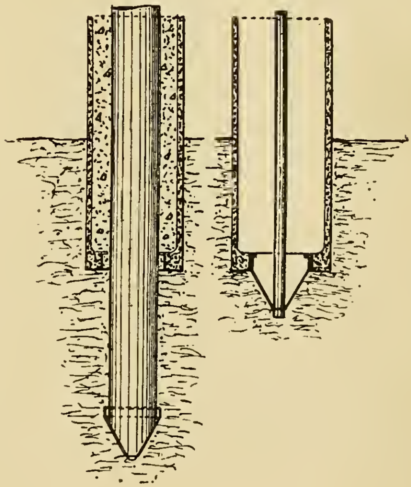


Fig. 7.



to enter the casing. It also serves to compress the soil at the bottom, which gives additional bearing capacity to the pile. It also forms a practical seal against the ingress of water between the pile and shoe, which will allow the water to be pumped out, and also any mud which may have entered, before placing the concrete filling.

Fig. 7 shows a case where, for some reason, it is desired to sink the casing with hydraulic jet first and then drive a wooden pile with a follower to a firm bearing through and below the bottom of the casing. The jet shoe of the casing is attached so as to disconnect easily from the casing, and is shaped so as to act as a shoe for the wooden pile.

Fig. 8 presents a case where rock or other firm stratum is reached. The bottom of the casing in this case is closed except for a connection in the center for a water jet pipe, by which means it may be placed in the usual manner. When proper bottom is reached, cement grout may be forced through this water pipe, which will serve to cement the casing to the bottom and give it a firm bearing.

Fig. 9 shows how an additional connection to the bottom may be made if desired. Drive with a follower a short steel pile, or pin, through the bottom of the casing after it has been sunk to place and bottom grouted. In this case the metal plate

Fig. 8.

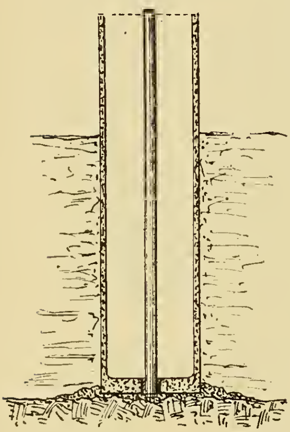
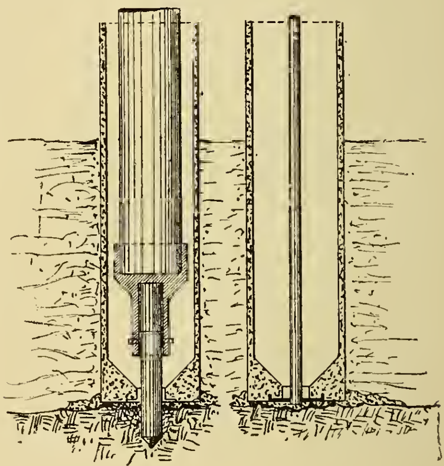


Fig. 9.



which closes the bottom of the casing, during the process of sinking, is so constructed that it will easily disconnect from the casing when the pile is entered, and the plate is of such thickness that it will readily shape itself to conform to the point of the pile when the pile is forced down to place.

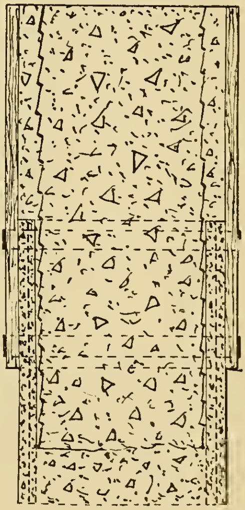
There is provision for making different lengths of piles by adjustment of the top sections. After the foundation is secured and casing built up, if the top section is found too long, this section may be removed and one of exact required length substituted. In case a section is found to be too short, or it is not convenient to remove it, when short, the pile may be lengthened, as shown by Fig. 10, by placing a circular detachable

form around the outside of the casing, placing the proper amount of reinforcing inside and filling the whole space with concrete, as desired. This same method may be used in constructing the upper concrete work shown in Fig. 4.

It would seem apparent, without going further, that it is easy to apply one or another of these examples to any requirement.

In closing, I may be pardoned for mentioning some of the advantages of this system over other similar forms of construction. Concrete, no doubt, being the principal requirement for good results, it becomes simply a question of using it in the best and most economical manner. If used in steel or wooden cylinders, the outer casing, it must be admitted, should be considered as only temporary, and the size of the concrete column is so made that, when the outer shell has served its purpose as a form, after due time, this concrete must stand by itself.

Fig. 10.



It being more or less difficult to determine just how successfully concrete in cylinders has been made, and also for various other reasons, the cross section of the concrete column is usually made large which gives a correspondingly large exposed surface to the action of water or waves in the pier. With this concrete casing the best and most durable part of the column is on the outside, and the cross section may then be materially reduced and, with it, of course, the exposed surface. This naturally leads to the question of cost or rather to relative cost of this construction. It may be easily demonstrated that since the volume of the concrete, which is the most expensive item, is greatly reduced, the price, complete in place, for the same length and bearing capacity of the structure is at least no more, and probably in most cases rather less, than that of any of the other methods used, even allowing for the more expensive outer casing, and I am very certain that its superiority is apparent.

[Note. Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by September 15, 1906, for publication in a subsequent number of the Journal.]

SMALL, VERTICAL, HIGH SPEED ENGINES.

By F. R. Still, Member Detroit Engineering Society.

Having had years of experience with various other makes of small engines, and comparing experiences of the past with those of the last three years, it has been found very difficult to avoid an almost exclusive reference to the one recently developed by an engineer associate of mine in the employ of the same company I am connected with.*

Therefore it is hoped you will bear with me a little, if my enthusiasm has biased my judgment in your estimation. Constant association with people, places and things always brings about a different aspect to us than to others not so much accustomed to them, which may be my case, though I can't believe it.

To most people, a small engine is something to be avoided if possible. It generally requires constant attention, frequent adjustment, is extravagant in steam consumption, and is difficult to get at to adjust or repair.

The main object of most manufacturers seems to be to see how cheap an engine can be built, not how good. This condition has so long prevailed that most people have concluded it is impossible to build a small engine from which the same results can be obtained as from a large one. The troubles to which small engines are incident are commonly accepted as a necessary sequence to their operation.

Efforts have been made to mitigate these evils by various schemes in design and lubrication, but usually the designer became so wrapped up in the one particular feature which started him into the design, that he lost sight of the other and more important details, never after being within speaking distance of them.

For example, one designer may start out to overcome vertical vibration, having a notion that in a multi-cylinder, single-acting engine there is less tendency to this vibration than in a single-cylinder, double-acting engine. An idea comes to him that if he could get compression on the downward stroke so as to slow up the movement of the reciprocating parts before they reach the end of the stroke, the necessity for heavy counter-

* American Blower Co., Detroit, Mich.

weights would be removed and a smoother running engine would be the result. So he sets out to accomplish this one thing, and very likely thinks out some scheme by which to introduce air compression toward the end of the downward stroke. He becomes so fascinated with this idea that all other details are almost totally neglected.

It would be fruitless for any one to attempt to make him see that the same thing can be accomplished in a double-acting engine, with a properly designed valve, so as to get the right steam compression at the end of the stroke.

Another designer starts out to build an engine with some "freak" valve, and every other detail is worked around this one central idea, regardless of efficiency.

Several have tried to reduce lubrication troubles, principally by splash oiling, with more or less success. If an engine is always in one position and always runs at high speed, this system may give fairly satisfactory results, but it is unreliable on board ships and at slow speeds. Furthermore, it is extravagant in the quantity of oil consumed. These examples will serve to show the usual trend of effort for the improvement of small, vertical engines.

From experience and close observation it was decided that fully 80 per cent. of the small engine troubles are due to improper lubrication; whereas only about 10 per cent. are due to inadequate proportions and finish of the working parts, and the other 10 per cent. to the neglect or ignorance of the operator.

It will thus be seen that if such conclusions are correct, the efforts of most of the designers have been in the wrong direction; that greater attention should be paid to proper lubrication and refining some of the details than to the production of something entirely new, with which there are likely to be as unsatisfactory results as before. Anything radically new is more likely to be misadjusted by the average engineer than something built on lines with which he is perfectly familiar.

Being so satisfied that these conclusions and deductions were correct, it was decided to carry them into effect, if with no other result than to prove their fallacy.

To get away from any fixed notions, and to gain new ideas from the practice of others and, further, to give "an opportunity to criticise somebody else," an engine designer of long experience in some of the best shops in this country was engaged.

Before him were spread these ideas, also what he was expected to accomplish. This briefly was as follows:

1. An engine that could be sold with a guaranty that it would run three months or more without requiring any attention, either to the oiling system, or for adjustments, except the filling of the sight feed cylinder lubricator.

2. An engine that would be economical in the use of steam and oil.

3. That could be easily adjusted and not liable to easily get out of adjustment.

4. That could be used anywhere and for any purpose that an engine can be used for.

5. That had ample bearing and wearing surfaces to make it long lived and unlikely to overheat at full load.

6. That it should be constructed of the best materials for the purpose intended.

7. That it should be devoid of any semblance to "freaks" of every sort; and last, but not least, and, perhaps, the most difficult of all, it must not be so costly to build as to make the selling price prohibitive to the average buyer.

How well these requirements have been accomplished is shown by the satisfactory reports since obtained from the engineers having charge of them.

Being so thoroughly impressed with the importance of a good system of lubrication, the first step was to work out something more effective than previously used.

It does not take much thought to arrive at the conclusion, that if metal does not run on metal, but is always separated by a heavy film of oil, there can be very little wear. The problem then settles down to the production of the necessary heavy film.

In looking over the many systems for lubricating engines, the most rational seemed to be forced lubrication by means of a pump. But experience shows this has many defects. The oil being under pressure necessitates extreme care in adjustment, as any bearing being looser than another vents the entire system and destroys the desired effect. Again, any foreign material that may get into the small tubes or grooves which are an essential part of this system will be rammed in tight by the oil pressure.

To overcome these objections it was decided to adopt a gravity flow, the oil being lifted by a pump to the top of the frame, from which elevation it would flow downward by gravity. In this way large tubes can be used; the velocity of the oil will be rapid, the volume of oil in circulation will be much greater,

it will not be necessary to have the bearings tight, neither will they all have to be adjusted exactly alike, and any foreign matter will be washed out, instead of being rammed in.

Being satisfied that this came close to the ideal way of producing the flow of oil, the next step was to distribute the oil along the bearing and wearing surfaces to completely separate them by that all-essential film.

For ages it has been common to groove the upper or lower half of the journal box or perhaps both. There are as many ideas on the proper way to groove a box as there are people in the business, and there are evidently many more who have no ideas at all, judging from the way it is sometimes done.

Considering the question from a mechanical standpoint, it is at once apparent that an oil film takes up space, so a bearing cannot be tight or the oil cannot get in unless it is forced in at a pressure greater than is exerted on the journal.

The thicker the film, the more space there must be between the metals, hence a loose bearing is desirable if it does not cause pounding.

When the crank is on the downward stroke, it pushes the journal away from the upper part of the bearing. The shaft is also rolling in the direction the crank is traveling. Hence, the oil should enter at the beginning of the gap which intervenes between the shaft and bearing and thence be rolled up into the remaining space by the rotation of the shaft. The gap naturally begins at one side of the circumference of the shaft, so the oil grooves should most naturally be on the sides.

After the crank passes the lower center on the up-stroke, oil should flow in from the groove on the opposite side in the same way. These grooves can thus be made large, say from $\frac{1}{4}$ in. to $\frac{3}{8}$ in. in width and the whole length of the bearing metal.

The same scheme is applicable to the oiling of the main bearings, crank pin, crosshead pin, eccentric and governor weight pin, and it works to perfection, better even than was ever thought possible.

To gain some idea of the way it is working, it may be in order to point out a few cases.

Cards were sent to nearly all the purchasers of these engines, asking them to have their engineer answer the questions printed thereon. The questions were as follows:

Size of engine?

When installed?

Revolutions per minute?

Steam pressure?

How often has oil been added since starting?

Quantity of oil added each time?

How often have adjustments been made?

Where have adjustments been made?

Replies were received in nearly every instance, and with the exception of five or six, they all ran over five months without any adjustments or additional oil.

One most exceptional case was at Davenport, Ia., where a 14 by 7 in. low pressure engine is running in a school building. The speed is 180 rev. per min., the steam pressure 40 lb. At the start 4.5 gal. of oil was poured into the base and in two years only one gallon has been added and one adjustment made, which was to the crosshead pin.

In New Orleans an induced draft fan was installed on an ocean tug, which is driven by a 5 by 5 direct connected engine. The steam pressure is 110 lb. The engine runs about 360 rev. per min. The outfit was installed in February, 1904, and up to November 29, 1905, about twenty-two months, only three gallons of oil had been put into the engine and one adjustment made to the crank pin. This engine runs continuously, 24 hr. per day for three or four days at a time. It is seldom that it ever stops entirely, as it is turning over slowly even when the tug is tied to a dock. It is located in a very hot place over the boiler and withal is operated under about the worst possible conditions.

At the plant of the Trexler Lumber Company, Allentown, Pa., is another engine driving a blower which is attached to a dry kiln. This was installed February 5, 1905, and up to November 18, 1905, only one gallon of oil had been added and one adjustment made to both the crank and crosshead pins.

This engine runs steadily at 285 rev. per min., 24 hr. per day, without stop for Sundays or any other day.

These few citations are sufficient to show the remarkable effectiveness of the oiling system.

There were many other problems in the perfection of this system which had to be worked out, that were, perhaps, equally as interesting in connection with this oiling system. For instance:

After the oil has performed its usual functions it must be filtered, cooled and the water separated from it. Any of the usual methods of filtration were found unreliable, as they all allow pieces of lint or grit to pass through. After much experi-

menting it was found that a plain closely-woven cloth suspended by four hooks from each corner of the frame, hanging just below the crank and above the oil in the base, gave the best results. All the oil dripping down from above lodges on this cloth and passes through to the reservoir below. Any foreign matter is left on top and has no tendency to leave the upper surface. Simple as it is, it has been surprisingly effective. As an extra safeguard a fine copper wire screen of ample area was attached to the pump suction and another to the discharge, both being easily removable for cleaning.

Another source of possible trouble which had to be guarded against is the loosening of core sand from the frame.

No matter how much care may be exercised in cleaning a casting, some sand is sure to stick for a while, loosen later and cause serious trouble.

To prevent this the frame is painted inside with two coats of thick white enamel. It took a lot of experimenting to get an enamel that would stand the heat, moisture and oil without softening, but it was finally procured.

The pump first adopted was of the plunger type, actuated by an eccentric on the shaft. It was thought too complicated, however, and was abandoned for a gear pump. On the shaft is a large bronze worm with coarse teeth into which meshes a small spur gear attached to a shaft supported at an angle of about 45 degrees. The pump gears are within a case attached to the outside of the frame close to the bottom of the base, where they can be gotten at at any time.

The discharge pipe from the pump is 0.75 in. diameter, and extends up inside of the frame to the top, where it discharges through a sight feed glass, so the engineer can easily see if the oil is flowing properly.

The oil then empties through a wire screen into a small tray, through the bottom of which latter project the various oil tubes nearly to the top of same. Each tube has a fine slit cut down the side of it to the bottom of the tray, so as to equalize the flow of oil into them all.

In adjusting the engine for this system no bearing should be so tight as to make it impossible to easily slide the connecting rod or shaft along parallel with its axis.

The success attained with these engines, while largely due to the perfection of the oiling system, could not have been attained if it alone had been the only thing carefully developed.

First of all, good material of the proper kind has to be used, and all the pins, rods, shaft, piston, valve, crosshead shoes, etc., must be ground on centers to a true diameter and smooth finish.

The shaft is a forging with suitable counter weights fastened on.

The connecting rod is a drop forging finished bright.

The crosshead is cast steel having brass shoes, wedge shaped and adjustable at the top and secured with lock nuts.

The crosshead pin is a special composition of a very fine grain and hard enough to take on a very smooth finish. This pin in combination with the brass used will not cut. The brasses have been set up as tight as they could be driven on a dry pin and the engine run all day without the least signs of cutting.

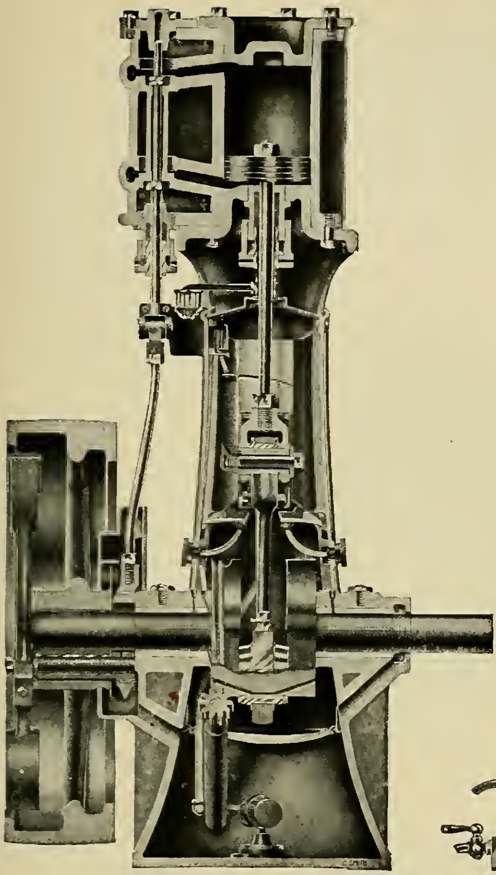
The piston rings are roughed out, cut, drawn together and clamped. They are then ground to the cylinder diameter. The crank pin brasses are lined with the best quality of Babbitt metal, peened in and scraped to a perfect surface. Adjustment to these brasses is accomplished by two tap bolts turned out of hexagon steel, threaded on the lower ends. Above the nuts the tops of the bolts are turned down to a smaller diameter and threaded again for a lock nut. The two tops are joined together by a yoke-shaped washer which is between the nut and lock nut to prevent either of the bolts working out if one of the lock nuts should loosen.

The fly wheel is so designed that the greater part of the weight comes in a plane close to the end of the bearing, thereby relieving to a great extent any strain on the shaft. The inclosing panels are held in place by a single milled thumb screw, thus overcoming the necessity for taking out a dozen or more screws to get off the cover plates.

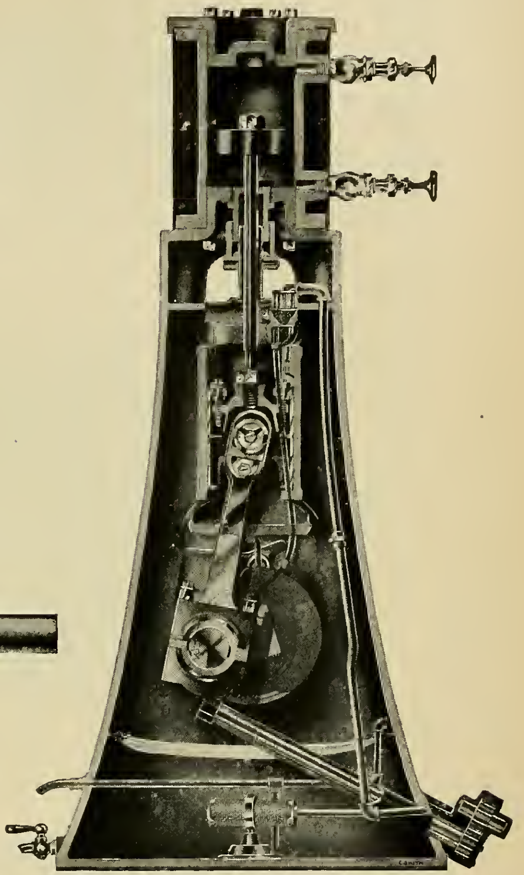
Every engine is set up, given a day's run under full load, and then taken down, carefully inspected, and if found in a satisfactory condition is re-assembled, indicated and adjusted before leaving the shop.

Due to the high speed, small clearance and a well fitting valve and piston the steam consumption has been brought down to an average of less than 37 lb. per h.p.hr. for a 6 by 6 engine, with 100 lb. pressure, when running 500 rev. per min. with full load.

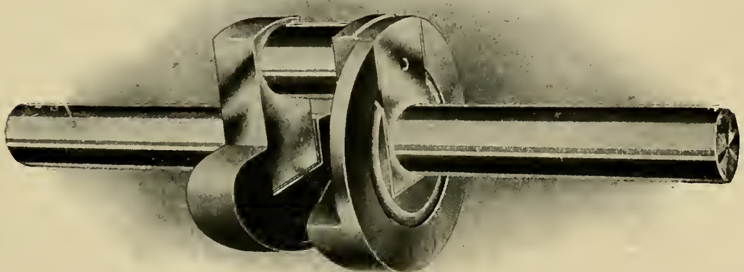
It is rare that the same economy is attained with other engines of the same size, as most of them take from 60 to 80 lb. per h.p.hr.



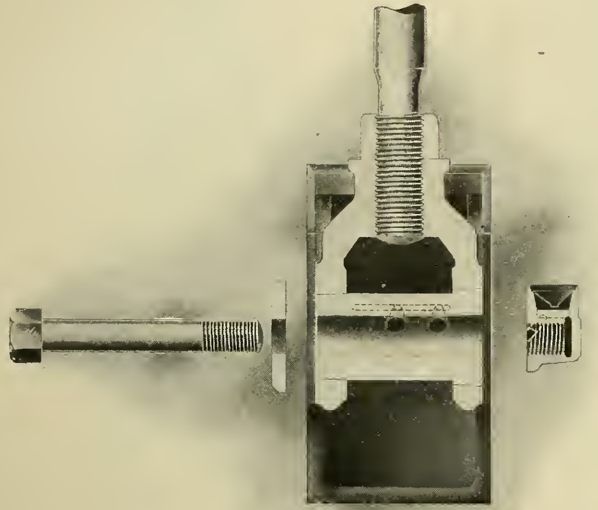
Longitudinal Section through the Engine.



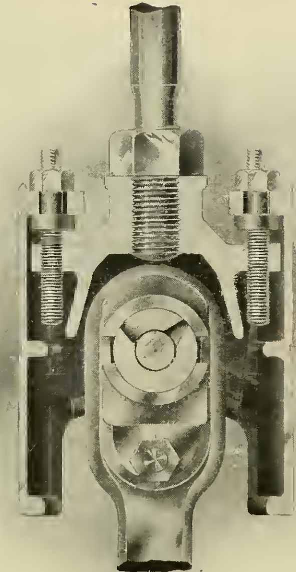
Transverse Section through the Engine.



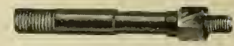
Crank Shaft.



Crosshead.



Crosshead.



Connecting Rod Bolt.

Connecting Rod.

It really seems as though about all has been accomplished in the design of these engines that can reasonably be expected in any engine.

They are machines, and as such are not "fool proof," but they can carry a heavy load, run at high speed, do with less attention and still perform their duty better than can the majority of engines.

[NOTE. Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by September 15, 1906, for publication in a subsequent number of the JOURNAL.]

FROGS AND SWITCHES.

By Robert E. Einstein, Member of the Engineers' Club of St. Louis.

[Read before the Club, January 3, 1906.]

In the consideration of frogs and switches, the section and quality of rail is an important factor. As generally designed they depend largely on the rail, and the durability and design of rail section has much to do with the safety and economy of their use.

The metal in our steel rail does not seem to come up to the requirements of modern traffic. The weight of rolling stock is constantly increasing. One hundred thousand lb. capacity cars and 100-ton locomotives are now in very common use. The volume of traffic has increased, so that it is probably tenfold what it was a few years ago. These are the conditions that the rails of the present day must meet. As to whether they are coming up to them or not, we have only to read the reports and discussions of the associations devoted to the maintenance of roadway and track. We find cases of 80-lb. to 100-lb. rails being badly worn and in poor condition after five or six years' use. We find innumerable reports of defective and broken rails, and a general feeling of distrust in the product of our rail mills.

In looking for the cause of these unsatisfactory conditions the general opinion seems to be, that the fault lies not in the chemical composition or cross section, but in the methods of rolling, and it is to bring about a better practice in this regard that most of the present efforts are being directed. The subject of rail, its composition, section and treatment in rolling is one that I can hardly do justice to in the limits of this paper. The importance, however, of the rail to that of the matter in hand will permit a few words relative to designs and sections in common use on steam railroads.

Up to the year 1893, the railroads, notwithstanding innumerable discussions on the matter by various bodies connected with their maintenance, had never been able to agree on a standard section of rail. It was the custom of the roads ordering large quantities, to have their engineers design a rail of the weight decided upon, intended to embody all the features

of perfection, and of such composition as to insure durability. In consequence, there developed numerous sections differing, more or less, from one another; in some the heads tapered up, others had sides of head parallel, and a few had heads with wide flat surfaces tapering down. For the same weight per yard, the heights varied one-half inch, bases one inch in width, and there were innumerable shapes and sizes for approximately equal weights, each having some feature to meet apparent former defects, or to conform to peculiar conditions of traffic on the road to be used. Something like fifty sections of rail weighing about 60 lb. per yard, the weight in general use at that time, were designed. This was very expensive all round. The rolling mills had to furnish or change rolls for every different shape. The railroad company had to keep on hand a various assortment of angle bars, fish plates, frogs and switches with their parts, to suit the numerous sections. Mills were hardly ever able to supply small quantities for renewals and extensions, which led to the use of a further assortment on the same road, with its consequent unsatisfactory results.

These conditions existed for a long time and were recognized as being anything but the best. It remained for the American Society of Civil Engineers to adopt, in 1893, what are termed the American Society of Civil Engineers' sections. The sections thus adopted vary from 20 lb. to 100 lb. per yard. The general features embodied are: Height equals width of base, sides of head parallel, top of head and sides of web to have a radius of 12 in., fishing angle in relation to center line 13 degrees. The radii of the corners vary slightly for the different sizes, the object being to maintain practically the same proportions and form for all weights. The head of these rails contains 42 per cent., the base 37 per cent. and the web 21 per cent. of the metal.

Within 10 years from the time of adoption something like 75 per cent. of the rail rolled in the United States was of the American Society of Civil Engineers' sections, which tends to indicate the favor with which a standard in this respect was taken up by mills and users. The experience of these years, however, in the use of American Society of Civil Engineers' sections, has tended to establish some changes. By comparing the American Society of Civil Engineers' sections, with a section of equal weight, 85 lb. per yard as recently adopted by some of the leading western systems, we find a tendency to get a deeper and a narrower head. The thin head of the American Society of Civil Engineers' rails is one of the apparent defects developed in their

use. This weakness of the head is more noticeable in the heavy sections, and experience has shown that some of the poor results are due to this cause. In frogs this is brought out to a greater degree than in ordinary usage, as the blow imparted by wheels in passing over flange way, or opening, is, in many cases, borne directly by the overhanging part of the head, and the thin metal causes it to pound down and break off very rapidly. The deep-headed sections are much more satisfactory in this respect.

In their earliest forms switches and frogs, like rails, were very crude and simple. The switch was of the stub pattern, in which the diverging rails were cut at a point where the gage lines are about 5 in. apart. The ends were held in position by cast-iron head chairs, so formed that they provided a seat for moving the sliding or switch rails from one of the stub ends to the other. The two sliding rails were connected and held to proper gage by bridle rods, connecting to base of rail by claw formed at each end, and thrown to position by some form of switch stand to which they were attached by means of a connecting rod. This form was used a great many years and is still found on unimportant sidings and very old tracks.

There were some changes made in the stub switch, tending to overcome its objectionable features which developed in the head chairs. To allow for the running of rails and the free movement of the sliding rails, a space of about one-half inch was necessary between their ends and the stub ends of turn-out. This caused severe pounding and consequent loosening and breaking of head chairs, and made the head block on tie upon which these chairs were spiked very difficult to keep up. As the speed and weight of rolling stock increased, trouble from these defects became more pronounced, and numerous derailments were caused by the weakness of the track at this point. The improvements made were in the construction of the chairs by substituting wrought for cast iron, and modifications in the form of stub ends by beveling to a V shape. But none of these overcame the practical breaking of the track with its consequent weakness.

For this reason the stub switch gave way to the split pattern now in almost universal use. This type of switch, it is claimed, was introduced in England as early as 1825, but did not come into general use until recent years, probably on account of the cheapness and simplicity of manufacture of the stub design.

In the split switch we have two of the rails unbroken, forming

what is known as the stock rails. The points or bevel rails are made by planing to proper shape rails of the same section as the balance of track. The usual length is 15 ft. or one half of a 30-ft. rail. In connection with 33-ft. rails, length is sometimes 16½ ft. with the same idea in view. In special cases points are also made as short as 7 ft. 6 in. for very short turnouts, and as long as 30 ft. for easy leads such as are used in cases where single track connects to double, or wherever high speed must be maintained in connection with diverging tracks. To overcome the weakness due to planing away a great part of the original section the points are sometimes reinforced by strips of iron or steel bolted or riveted to the web. This reinforcement is also made in the form of a tee or angle to give additional lateral stiffness.

Like the stub switch, points are held to proper gage and position by bridle or switch rods. They differ in form and manner of attachment, however, on account of the rail being greatly reduced in section at some of the points of application, and because there is not the required space for applying rod of the claw form. There are a number of methods of connecting points to rods — all designed with the idea of allowing a certain though small amount of play for the free movement of the points. A common and very satisfactory form is the fork attaching with pin to the base of rail. This keeps the points well up to their proper working position, and has no bolts or extra pieces to get loose, rattle and give trouble. It also has the advantage of being at the bottom of the rail, away from liability of coming in contact with wheel flanges. Another form of attachment in general use consists of pressed steel clips or brackets, bolted to web of rail, with recess open on one side for the ready application of rods. Pins or bolts pass vertically through clip and rod holding points to proper gage and allowing for free movement. These two are only examples of the many in use.

The rods were formerly made to fixed lengths, but recently an adjustment of some kind to allow for variation in gage or throw and to take up wear and lost motion is incorporated, either in the rods or clips. There are a great many ways for providing for this adjustable feature. The simplest, and probably the most common, is the turn-buckle or swivel. This is simple and easily understood by the class of labor usually employed on track and, when properly made, makes a very acceptable type of adjustable rod. Other forms, such as wedges,

eccentric bolts, saw teeth formed on rod, and a series of holes allowing for changes in length, are used and have various advantages that have led to their adoption.

In the old forms of split switch having rods of fixed length and points without reinforcement, four rods were considered necessary. This probably came about through its evolution from the stub switch. There is hardly any good reason for the use of more than one, or at the most two, rods on a 15-ft. or $16\frac{1}{2}$-ft. switch, except, it is claimed, in case of breakage to point, that the back rods tend to hold rails to safe position for passing trains. This possibly accounts for the long-continued use of the four-rod switch. With reinforced points the reinforcement serves as a protection in case of breakage, as well as stiffening to points, and one or two rods are enough to keep them at proper distance apart, and to move and hold them to position.

Besides the points and rods, split switches require plates, which reduce friction of moving rails, form a shoulder to hold stock rail to proper position and keep center of point slightly above the stock rails. The latter function is one of great importance, preventing the liability of a side strain and consequent turning over of these rails, due to worn treads passing from heel to point of switch. Many of the accidents reported as caused by spreading rails can be attributed to this cause.

Plates are usually made from $\frac{1}{4}$ in. to $\frac{1}{2}$ in. in thickness and from 4 in. to 8 in. in width. The part of plate under point is raised to allow for an elevation of from $\frac{1}{4}$ in. to $\frac{3}{8}$ in. to switch point above stock rails for the purpose set forth. These plates are usually placed under about $\frac{3}{4}$ of the length of point. They are designed to allow for the use of a rail brace against outside of stock rail, serving to hold track to gage and prevent the tendency of stock rail turning over from side strains. The plates directly under points are often combined in one, extending across the track and forming a gage plate.

There have been other forms of switches designed to overcome apparent defects of the split pattern, but very few of them have come into general use. The Wharton switch is probably the only one that has had extensive application. In this the wheel flanges are raised over the main rail on inside of turn-out, while a point similar to split switch is used on the opposite side. The objection to this switch is the excessive cost and the fact that a slow rate of speed is necessary in taking the turn-out track, making this type only adapted for turn-outs where siding has infrequent use.

The means of operating switches except at terminals, and locations where their number within a limited space permits the use of interlocking plant, is by some form of switch stand.

The types of stands vary according to their use. For main line a stand having signal from 7 ft. to 20 ft. in height for indicating position of switch, with lamp attachment serving same purpose, is used. It is the practice on some roads to connect important switches with a distant signal located from 1 000 to 1 200 ft. from switch, and so connected that this signal always shows position of switch, giving the engineer an opportunity to discover in time any chance misplacement.

With the block system this safeguard is, of course, provided through connection of signals with the switches, but as a very small proportion of our mileage is thus equipped, the distant signal in connection with main line switches affords a great factor to safety in operation.

In yards where switches are moved frequently, and where the temptation and chances of running through them are great, the stand best adapted is a form of automatic ground throw with lever throwing parallel to track. The automatic feature allows for this running through switches without serious results, the lever being of such weight that the action of wheels against the points throws it over. Making the movement parallel to track permits its use where distance between the tracks is very small, thereby economizing space. Yard stands are equipped with small targets and lamps which are kept close to the ground to avoid interference with cars.

In the form, size and color of targets there is a great variety. The *forms* of signals should differ for clear and siding positions, though sometimes this is not the case. In *color*, white is always the clear position, while red or green is the opposite indication. The night signals are made to conform to the practice of road, either red and white or red and green as the custom may be. There has been a great deal of discussion on the matter of signal colors, and a uniform practice in this respect is much to be desired.

In the construction of switch stands cast iron, malleable iron, wrought iron, cast steel and structural shapes are all used. It is important to avoid complicated mechanism, interference by snow and ice, and to allow for easy operation, repair and renewal of parts, while cost has its usual consideration.

The frog is that part of turn-out where the lead rail of switch crosses or intersects the main rail. The term is also applied to

the intersection of two tracks, which properly form four frogs, and is usually referred to as a crossing frog, or simply crossing.

Frogs have been standardized as to angle; that is, there are certain angles or numbers in general use; but the construction or types vary a great deal. In the standardization of angles they are termed according to *number*, which properly is the relation of the spread or divergence of rails to the distance at which it is measured. Thus a number nine or a one in nine frog indicates that the spread is 1 ft. at a distance of 9 ft. from the intersection of gage lines. The number, of course, determines the angle, being the difference in the direction of the rails along the running line: thus a spread of one in nine makes angle of 6 degrees 21 minutes. This angle likewise determines degree or radius of turn-out curve and the lead or distance from the point of switch to point of frog. Referring to frogs by number greatly simplifies the matter of turn-outs. Trackmen easily understand the difference between the sizes, and the engineer is able to stake out his turn-outs according to uniform rules, and to design his yards to conform to the standard numbers or angles adopted to suit the various conditions. As the number or angle determines the radius or degree of turn-out curve, it is simply necessary to establish certain sizes of frogs for the different purposes. For main line turn-outs and cross-overs frogs from numbers nine to eleven are the recognized standards in common use. It is, of course, impossible to adhere to one angle under all conditions, but it is the endeavor to conform in all but special cases to the angles adopted as a standard. For very easy turn-outs such as the merging of double into single track or where high speed must be maintained, frogs from No. 18 to No. 25 are used, while in close places where space is limited, frogs as small as No. 3 or No. 4 are sometimes necessary. The latter are, however, special cases to be avoided if possible, as it makes a very sharp and unsatisfactory curve.

The usual yard frog is a No. 7; Nos. 6, 8 and 9, however, are in common use for this purpose. The angle is determined by the space available, and with an idea of economy of time and space for rapid, easy and safe movements. One of the greatest economizers of space in yards is the slip or puzzle switch This is really a crossing or intersection of two tracks, at such an angle as to permit the use of ordinary end frogs in combination with four switches, thus giving four movements within its limits. The angle to which slips can be applied is limited by the same conditions that govern frogs, that is, an angle less

than No. 6 makes the curvature too sharp for practical use. On slips longer than No. 7, it is necessary to make the center frogs of the movable point pattern to prevent derailment from inadequate guarding of the center frog points, which is practically impossible on account of frog points being exactly opposite.

In short slips the wings of center frogs offer the same protection at this point as do guard rails opposite end frogs, but when angle exceeds No. 7, the two points of each center frog become so far apart, that ordinary wheels are sometimes inclined to get the wrong side with serious results.

The use of movable center points instead of rigid center frogs obviates the necessity of guard, and makes a safer and more durable slip. The only objection to this form is the fact that these points must be thrown the same as a switch, and the trouble experienced has been that the switchmen do not always move them to the correct position with relation to the end switches. This, however, has been overcome by the proper connection of the end switches and center points, and the use of interlocking switch stand with required movements. The center points are thus always held in the proper relative position to end switches, and no derailment can occur from this cause.

Frogs may be divided into several classes: For main line use American railroads have now practically adopted the spring rail frog; for yards and ordinary sidings away from high speed traffic, the rigid frog is generally used. In the construction of spring rail frogs there has been a number of improvements during the past fifteen years, tending to increase safety. The earlier forms of this frog were so imperfect that a great many serious accidents have been traced directly to their use, and on some roads they became such a frequent cause of complaint that the use of spring frogs was for some time abandoned. The defect developed was the long loose rail on the main line. This rail, as the name of the frog implies, is held to proper position by a spring, so arranged that under ordinary conditions it lies close to the point of frog, forming a smooth surface for passage of wheels on the main track. In taking the siding this loose rail is forced out by the action of the wheel flanges, the fish plate or angle bar at its end acting as a hinge for its movement. By frequent use this loose rail has a tendency to rise or stand proud of the surface of frog, and although precautions were taken to prevent this, it was very often the case that a combination of this long loose rail with the tendency to rise and a badly worn

wheel, acted so as to turn over the rail with consequent serious results.

In the spring frog having hinged spring rail, the possibility of accident from this cause is entirely averted. The spring rail is only movable or loose for about 2 ft. on the main running line. It is reinforced by an outside rail which in addition to strengthening this weak part of the frog gives the movable part so wide a base bearing that any possibility of the rail turning is entirely overcome. There are additional safeguards and improvements in this frog that make it practically as safe as the rigid, with all the advantages in durability and smooth riding of the spring frog.

Other forms of spring frogs embodying the old principle of the long loose rail have been equipped with improved devices, and under ordinary conditions are reasonably safe, but even the chances of accident, when it is possible to prevent it, should condemn the use of any but the most improved devices where the lives and property of the public are concerned.

In the construction of rigid frogs three general forms are used, — the bolted pattern, in which the parts are held together by means of bolts; the plate riveted, having the rails riveted to a large base plate, and the clamp or yoke design with steel or wrought clamp and wedges to hold rails and filling blocks rigidly together.

Rigid frogs, and crossings which are practically a combination of frogs, have the very necessary evil of a flange way or opening for the wheel flanges. The passage of the wheels over this opening, with the heavy loads of modern equipment, is the cause of the rapid pounding out and frequent renewal of frogs. When we consider the difficulty experienced in keeping up an ordinary rail joint, where the distance of from $\frac{1}{32}$ in. to $\frac{1}{4}$ in. between the rails causes a rapid battering of the ends, we can comprehend the effect of the same loads on the crossing or frog where this opening is necessarily increased to from $1\frac{3}{4}$ in. to 2 in. It is to overcome the rapid pounding out of rigid frogs and crossings that a great deal of thought and experiment has been devoted for the last few years. In construction we have arrived at a point where the frogs are so rigidly put together that it is no longer a question of working loose and shaking to pieces. It is clearly a case of providing one of two things: to do away with the cause of pounding, or to overcome the effect. Towards the first, the spring frog on main line provides unbroken surface for passage of wheels, but only on one side of frog; we have

likewise the double spring frog doing away with opening on both sides. The latter is an improvement over the rigid, but the constant movement, due to each wheel acting against the spring, makes this form of frog extremely hard to maintain as the parts get loose and fall apart; although the life is considerably longer than the ordinary rigid type.

On lines similar to the double spring frog the sliding or movable wing rail frog offers also an unbroken surface, and on a frog of this kind built on the principle of the hinged spring frog we have again the advantage of short moving rails having fixed ends to rigidly bolt the connecting rails. Frogs of this type have had, under the hardest conditions of service, a life of three to five times that of ordinary rigid frogs.

Crossings of the smaller angles are built on the same lines as frogs, and involve the same weakness and defects. As the angle becomes greater or nearer to 90 degrees the construction changes to suit conditions.

From 35 degrees to 90 degrees crossings, as generally made, consist of a frame or filler of wrought iron or steel, to which are bolted the rails. The filler is a rolled section fitting the fishing angle of rails with required flange way opening and depth. The rails are milled or planed to form at the corners the necessary bearing for tread and flange way for wheels, and are further supported by straps fitting between head and base from 1 in. to 2½ in. in width through which pass the bolts that hold these parts rigidly together. Plates from ¼ in. to 1 in. in thickness are placed under corners to distribute the shock or pound to the ties.

The most important and generally adopted improvement in recent years in the construction of crossings is the reinforcing or easer rail. This rail, in addition to providing strength to the structure, acts as a means of preventing the overhanging wheel tread, often badly worn, from striking the abutting rails, which causes the rapid loosening and shaking to pieces of the crossing.

The use of the heavier rails, reinforced construction of frogs and crossings solidly bolted together has resulted in the loss of that elasticity that the lighter forms of construction embodied. As previously stated, it was either necessary to remove the blow or overcome the effect. The tendency on heavier construction is to increase the force of the pound, as the shock is borne directly by the rail and the stiffness of structure does not transmit it to ties and road bed. If our rail was of better quality this would be overcome to a great extent, but with the poor metal

and the thin heads of the American Society of Civil Engineers' sections the question of increasing the life of crossings and rigid forms of frogs has led to the use of a metal at the points of wear that combines with hardness the quality of toughness to prevent fracture. This form is known as hard center construction, and is now receiving a great deal of attention.

The idea of making the parts of frogs and crossings subject to shock of a harder substance than rail is by no means of recent date. Street railways have used this form almost with the advent of electric traction. In this service, however, there are several important conditions that do not enter into steam service. The speeds are, under no condition, what they are on steam railways, and when they do approach the high speeds of main line service as on interurban roads, the same forms of construction are usually used. It is also the general practice on account of the narrow treads of street railway wheels to give the wheel flanges a bearing in passing over the flange ways of frogs and crossings. At slow rates of speed this is not liable to injure the wheels, and does away with a great deal of the shock. These conditions, and the deep solid forms of construction in street railway practice, have practically made hard center material the recognized standard for this service.

On steam railroads where we are confronted with higher speeds and cannot allow a flange bearing, it is possible that extreme hardness when generally used will save on the frogs, but may develop other defects and expense that more than counteract the economy in this respect.

At present frogs with hard centers are being tested under conditions where traffic is exceedingly hard, and where maintenance of frogs forms a considerable item. There are many places, where 60 to 90 days represent the life of an ordinary frog. If the substitution of the hard center of the sliding feature adds to the life enough to pay for increased cost, and offers no counter expense to equipment, there is no doubt that the future will see increased use of these types, even at an outlay of from two to five times the cost of ordinary construction.

The metal that has thus far proved the best for hard centers is a cast steel containing a certain percentage of manganese. The cost, of course, runs high as compared to other forms, but for hardness and toughness, the qualities most desired, it seems to fill all requirements. The expense attending the use of this metal is further augmented by the cost of working, as its extreme hardness makes it necessary to cast it very closely to its final

form. All holes must be cored, as no tool steel has been found of sufficient hardness to drill it, and all surfaces and joints must be ground, because planing or milling is impossible for the same reason.

The failures in this metal due to improper mixture or handling sometimes cause cracking or chipping. When this is the case its use is attended with danger; but this defect is not insurmountable, and we may expect to see the use of hard wearing surfaces not only in the future development of frogs, crossings and switches, but also in the rail, thus bringing about a much-desired factor in the development of our railroads.

[NOTE. Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by September 15, 1906, for publication in a subsequent number of the JOURNAL.]

ASSOCIATION OF ENGINEERING SOCIETIES.

Organized 1881.

VOL. XXXVI. JUNE, 1906. No. 6

A SUGGESTED SOLUTION OF METROPOLITAN TRANSIT.

BY W. JONES CUTHBERTSON, MEMBER OF THE TECHNICAL SOCIETY OF THE PACIFIC COAST.

[Read before the Autumnal Meeting of the Society, December 15, 1905.]

ALTHOUGH I am not a professional engineer, the subject of which I treat is so apropos at the present time that probably no apology is needed for bringing it before you, even under the adverse circumstance of its being treated by an amateur.

It is proposed to exhibit a method of running railroad traffic in public streets which I believe has not yet been sufficiently exploited, referring especially to San Francisco, to which it is peculiarly applicable.

Street railroads may be run on three different planes in relation to the ground level: Below the surface, on the surface and above the surface. This may be exhibited by vertical sections showing ways of arranging the common road and the railroad, the lines indicating the before-mentioned planes.

(1)	(2)	(3)	(4)
o	o	railroad	common road
common road	common r'd & R.R.	common road	railroad
railroad	o	o	o

(1) is an example of railroad beneath the surface of the ground.

(2) is an example of railroad and common road on the surface at the same level.

(3) is an example of railroad elevated above the surface.

(4) of railroad on the surface and common road above it.

1. Sewer.
2. Scavenger service tracks.
9. Subway walk.
11. Sewer manholes.
12. Water main.
13. Gas main.
14. Steam main.
15. Pneumatic tube.
16. Electric conduits and wires.
17. Rapid transit subway tracks.
18. Glass tile lighting railroad subway.
19. Ventilating grating for railroad subway.
20. Columns supporting high-level roadway.
21. Columns supporting high-level sidewalk.
23. Local car tracks.
24. Platforms.
25. Stairs or bridge connecting high- and low-level.
26. Roadways for freight.
27. Low-level sidewalk.
28. Glass tile lighting pipe subway.
30. Trusses supporting sidewalks.
31. Trusses supporting upper roadway.
37. High-level roadway.
38. High-level sidewalk.
39. Bridges.
43. Parapets around light areas.
45. Upper sidewalk lights.

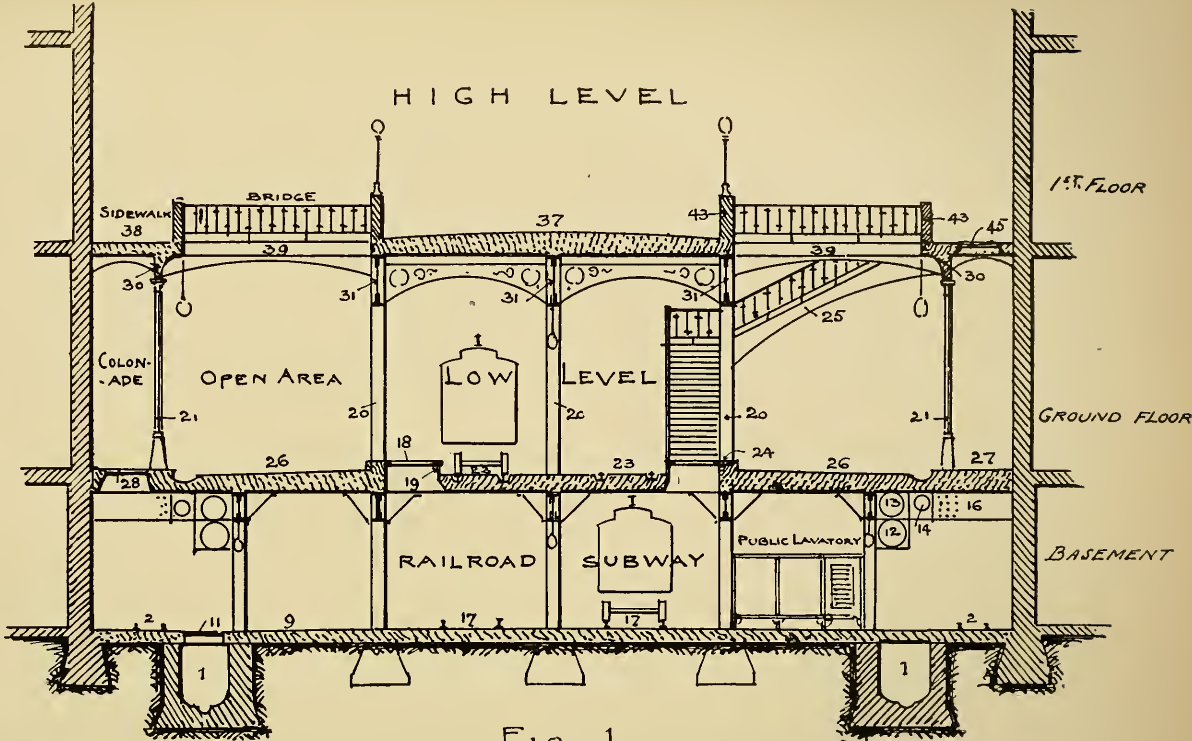


Fig. 1.

CROSS SECTION (X) OF STREET, SHOWING RAPID TRANSIT SUBWAY.

Scale 0 5 10 15 20 25 FEET
0 1 2 3 4 5 6 7 8 METERS

Copyright by W. J. Cuthbertson 1900.

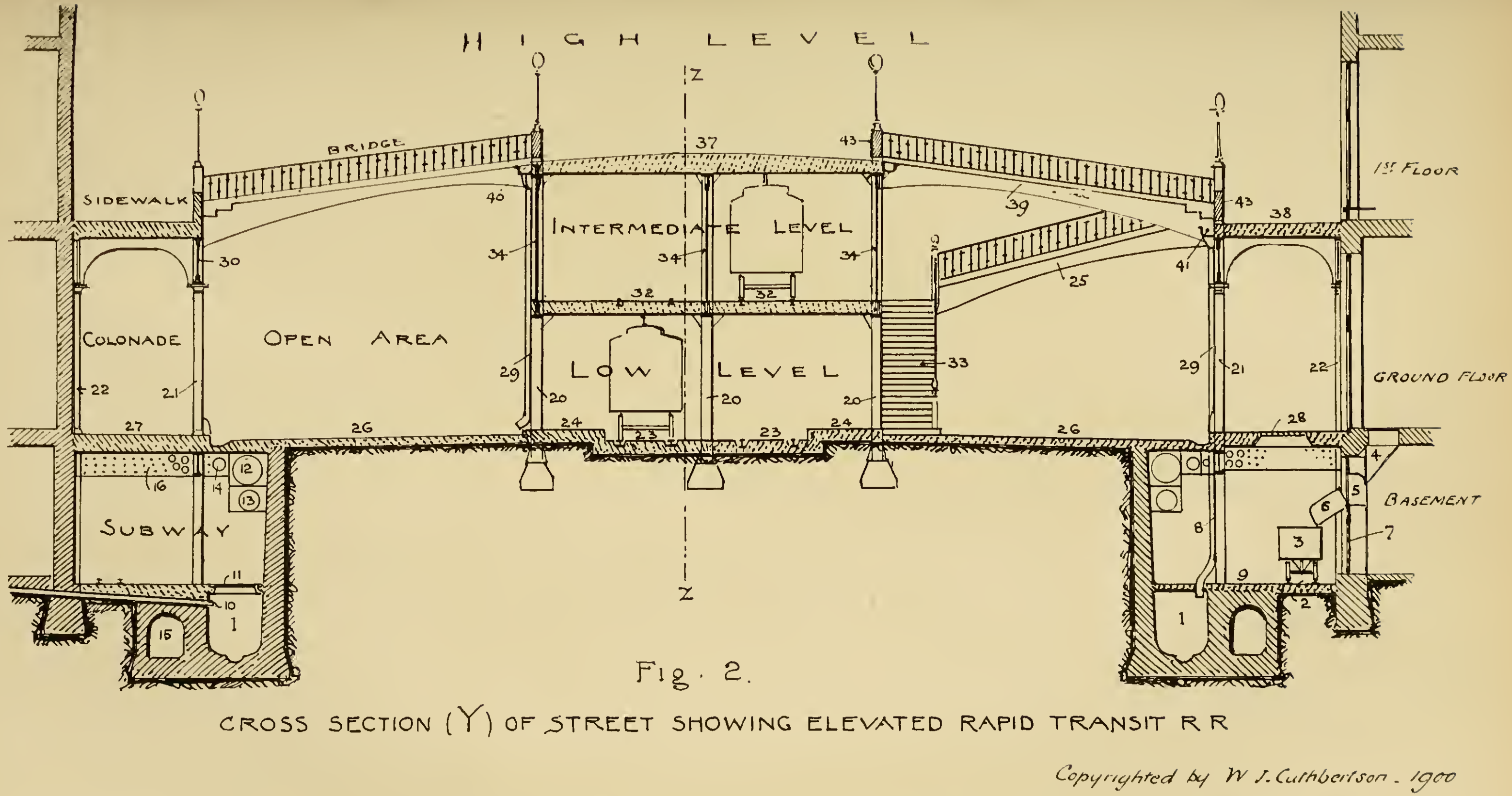


Fig. 2.

CROSS SECTION (Y) OF STREET SHOWING ELEVATED RAPID TRANSIT R R

3. Scavenger service dump wagon.
4. Refuse chute.
5. Refuse bin.
6. Same tipped, delivering into dump wagon.
7. Grille inclosure of basement.
8. Low-level rainwater pipe.
10. House drain.
22. Stanchions against wall of building.
29. Rainwater pipes from high-level.
32. Rapid transit elevated tracks.
33. Stairs to low level.
34. Trusses supporting rapid transit and carriage roads.
40. Gutters of high-level roadway.
41. Gutters of high-level sidewalk.

All these arrangements have been tried except (4), which is the subject of the present paper.

Before considering anything new, it is advisable to find out whether existing conditions are bad enough to warrant a change, and if so, whether this change will bring about something sufficiently superior to warrant its supersession of the old. Therefore, before going further, let us look at the systems now in use and see wherein they are objectionable.

Generally the objections to the systems now in use may be taken as follows:

1. Railroad below Ground.
   - Cannot be used for local traffic.
   - Costly.
   - Unhealthy and unrecreative.
   - Interfering with sewerage and pipage.
   - Accidents intensified.

2. Railroad on the Surface and on Same Level with the Common Road.
   - Cannot be used for rapid transit.
   - Very dangerous.
   - Inconvenient and therefore uneconomical for both railroad and other traffic.

3. Railroad Elevated above the Surface.
   - Cannot be used for local traffic.
   - Hideous.
   - Annoying to residents on the route.
   - Accidents intensified.

I belicve that this indictment of our present means of municipal transit is sufficient to warrant an investigation of arrangement (4), which it is claimed will avoid all these objections.

To appreciate its comparison with the other examples, it will be well first to consider the practical method of carrying it out. Figs. 1 and 2 represent what might be called a two-storied street. It will be noticed that there are three horizontal divisions, the lowest being the subways for sewers, water and gas pipes, electric wires, steam pipes, pneumatic tubes and all the other carrying apparatus which are now necessary for our civic life; the middle one for the railroads and heavy traffic, which we shall call the low level or lower street; and the roadway above this, supported by posts, beams and arches for light travel

and promenading, which we shall call the high level or upper street.

Taking these in their order, we shall first consider

The Subways.

These are located on each side of the street next to the building line.

The enclosing walls and the floor are made of concrete. Along the center line is built the channel for sewerage. The flow in the sewer is regulated by sluices at proper points so that the channel may be periodically flushed. Salt water is used during the rainy season, where obtainable. The subway patrol attends to this and all other matters in regard to watching, cleaning and keeping in repair the subways. On each side of the sewer are walks. The pipes, tubes and conduits are carried by iron brackets or shelves fastened to the ceiling. On the walk nearest the houses is the narrow track for the scavenger trains hereafter mentioned.

The size of the subway varies in accordance with the demands made upon it. Its walls are lined with glazed white tile. The roof is supported on steel beams running from wall to wall, filled in with concrete, glass tiles forming the sidewalk above, as is shown in the illustration; the rest of the subway roof forms part of the road and its gutter. The rain water from the high level is carried from a catch basin through iron pipes to the low level, from which they empty directly into the sewer below as shown (8).

In the inner wall of the subway are ensconced the ash bins, one to each house, projecting towards the basements, into which is delivered all the solid waste matter of the houses. These bins are made to tip outwards when desired, and the contents are thrown into the dump wagons (shown in Fig. 2) drawn by electric motors, which empty these bins and carry the waste to the incinerators. Stairs are placed at each corner of the main streets and at the railroad platforms, so that pedestrians and passengers may descend to the subway and cross under the street, and also get to the public lavatories, which are placed adjacent to the subway where deemed necessary.

The Railroad Subway (see Fig. 1).

The subway for the rapid transit railroads is to run on the cross streets and is built in the same manner as the sewer subway. The platforms of the road above are floored with glass tile and

their risers are made of metal gratings, admitting light and ventilation through the ceiling of the railroad subway. In the center of this subway are arranged the steel columns which support the ceiling and which are carried up to the high-level roadway, which they support in the same manner.

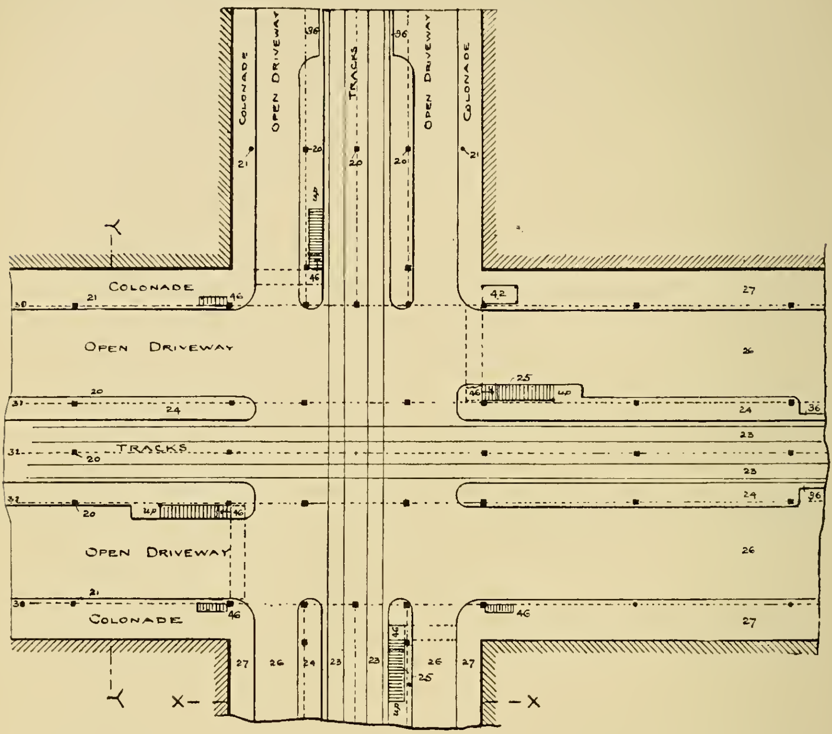


Fig. 4. Plan of Low Level Streets

Copyrighted by W. J. Cuthbertson 1900

20. Columns supporting high-level roadway.
21. Columns supporting high-level sidewalk.
23. Local car tracks.
24. Platforms.
25. Stairs or bridge connecting high- and low-level.
26. Roadways for freight.
27. Low-level sidewalk.
30. Trusses supporting sidewalks.
31. Trusses supporting upper roadway.
32. Rapid transit elevated tracks.
36. Curbs to prevent teams passing over tracks.
42. Elevator.
46. Stairs to subway for passengers to cross under road and to public lavatory.

The Low Level.

The low level corresponds with the present street level.

In the center run the local cars, picking up and setting down passengers at any place they may desire. Their tracks run alongside the longitudinal platforms or pathways running between the tracks and the vehicular traffic and acting as a

preventive to teams crossing the tracks except at certain intervals and as platforms for passengers of the local cars.

On those streets where rapid transit cars run, the rapid transit tracks, except where before mentioned, are placed over the local tracks and between them and the carriage road above, as shown in Fig. 2. In consequence, however, of the gain in speed of the local cars, arising from their tracks being freed from all other traffic, rapid transit railroads will be required to a very limited extent.

The space of the street outside the local tracks is a roadway provided with longitudinal granite trams, devoted to heavy teaming and for loading and unloading into the ground stories.

To epitomize, the arrangement of the low-level street from center line out is as follows:

1. The central row of columns (20).

2. Local trains, with rapid transit trains over, where used (23).

3. Intermediate platform (24).

4. Freight roadway and space for backing up and unloading goods (26).

5. Narrow sidewalk next to ground floor front of buildings, width depending on width of street (27).

The High Level.

In the center is a roadway for light traffic and pleasure vehicles; then comes an open light and air area for the low level, railed in; finally the sidewalk, for promenaders and for those who desire to look at the shop displays, as on this level are the main store fronts.

Frequent bridges connect the roadway with the sidewalk, and provision is made at each intersection of sidewalks for people to get from one level to the other. This is effected by stairways or inclined planes running from the sidewalks at the crossings of the streets to the lower platforms, as shown in plan on Figs. 4, 5 and 6.

A public elevator will run from the high to the low level at these crossings. At intermediate places the public desiring to go from one level to another will use the elevators of the stores, which the shopkeepers will gladly allow as a means of publicity.

To avoid any level crossings on the rapid transit tracks, those on streets running in one direction are placed over the ordinary street cars, while those running in the other direction

are placed in a subway. These latter rapid transit cars will be those of cross-town lines, such as the Filmore, Larkin and Kearny street lines in San Francisco. The sewers are low

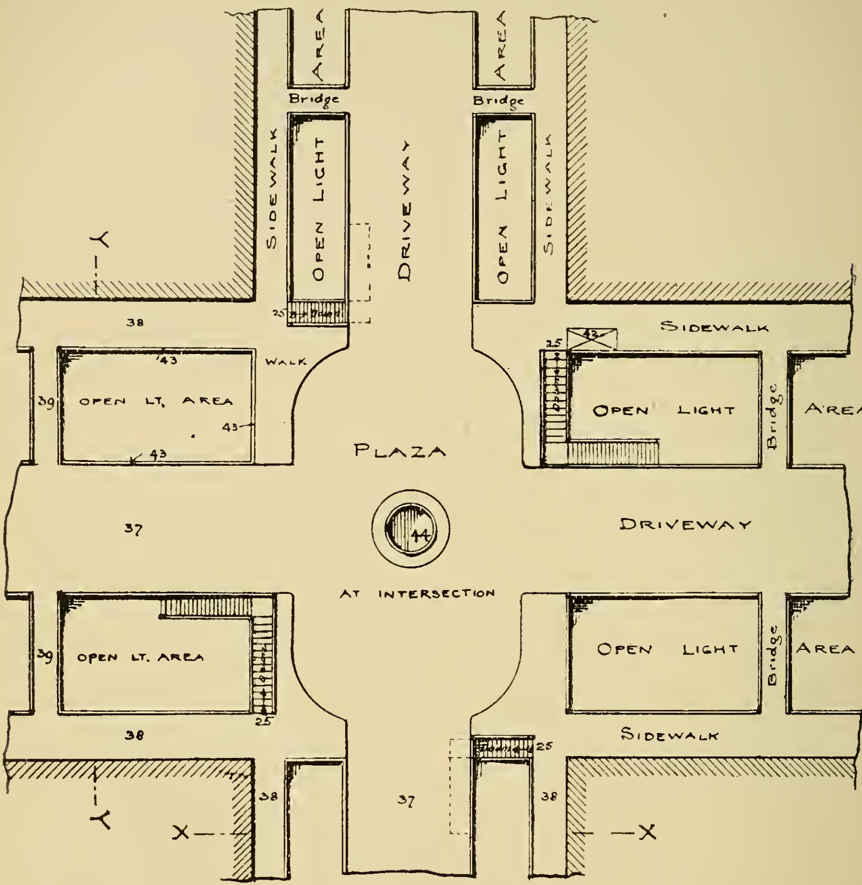


Fig 5. – Plan of High Level Streets

Copyrighted by W. J. Cuthbertson 1900

25. Stairs or bridge connecting high- and low-level.
37. High-level roadway.
38. High-level sidewalk.
39. Bridges.
42. Elevator.
43. Parapets around light areas.
44. Central light well and Island of Plaza.

enough to run under these railroad subways where crossing them, and the other pipes generally run over them.

One of the stations of the rapid transit railroad placed on the intermediate level is shown in Fig. 6 and its connections by

stairs with the high and low levels. Its connection with the local cars of cross streets, in which case the platform will be in the middle of the street, is also shown. In fact, in all narrow streets the platform between the tracks in the center of the

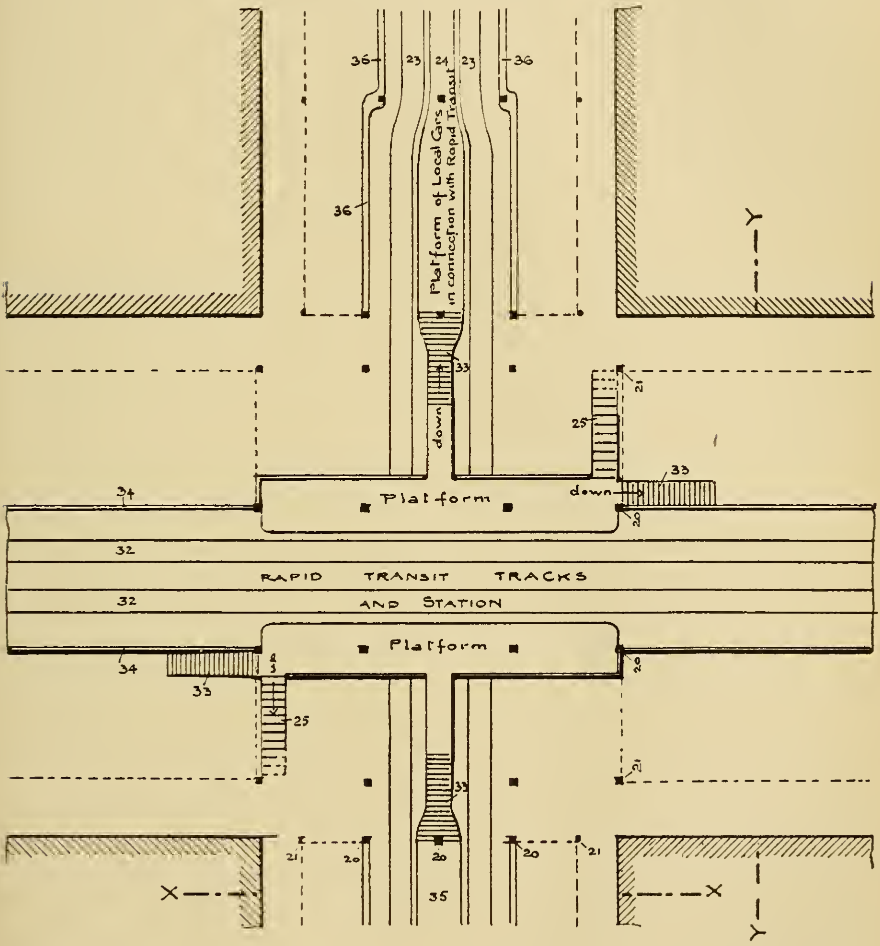


Fig. 6. Plan of Intermediate Level

Copyrighted by W. J. Cuthbertson. 1900.

20. Columns supporting high-level roadway.
21. Columns supporting high-level sidewalk.
23. Local car tracks.
24. Platforms.
25. Stairs or bridge connecting high- and low-level.
32. Rapid transit elevated tracks.
33. Stairs to low level.
34. Trusses supporting rapid transit and carriage roads.
35. Platform of local cars at rapid transit station.
36. Curbs to prevent teams passing over tracks.

street will be preferable to the arrangement shown in Fig. 4, as it will allow more space for teams.

Inclined roadways for the use of vehicular traffic connect the high and low levels at convenient intervals. On those streets where there are elevated rapid transit railroads, these connecting roads or inclines will naturally be of somewhat greater length than required for streets where no rapid transit railroads run, due to the greater height of the high-level road. In hilly cities, such as San Francisco, however, the configuration is such that advantage can be taken of the adjacent risings of grade for these connecting roadways, as we shall describe later on.

Superstructure Construction.

The superstructure consists of rows of columns of steel or other material, which may be from 30 to 50 ft. apart, supporting lattice girders or arches as shown on the longitudinal section, Fig. 3. On these rest the cross steel beams carrying corrugated arches filled in with concrete or any other approved system for the roadbed and sidewalks of the high-level street and for the rapid transit railroad where used.

Bracing and tying this structure are the steel arched or suspended bridges, which connect, at intervals of about 100 ft., the roadway and the sidewalks. They have ornamental railings and newels forming lamp-posts and are about 6 ft. wide. The structure is strongly anchored to stanchions built into the walls of the buildings on each side, thus forming a rigid whole.

In those streets where the rapid transit trains run above the locals, the upper roadway is higher than the sidewalks, thus giving the bridges an incline and giving height for both sets of cars between the high and low levels. (See Fig. 2.)

This brief description gives a sufficient idea of the construction for our purpose, and we will pass on to the next subject.

A Comparison of This System with the Ones now in Use.

Taking up the subject systematically we shall compare them in regard to the following:

1. Public safety.
2. Health and recreation.
3. Economy and convenience.
4. Artistic effect.

1. PUBLIC SAFETY.

The present mode wherein car traffic and all other traffic are together on one roadway is a menace to public safety. The

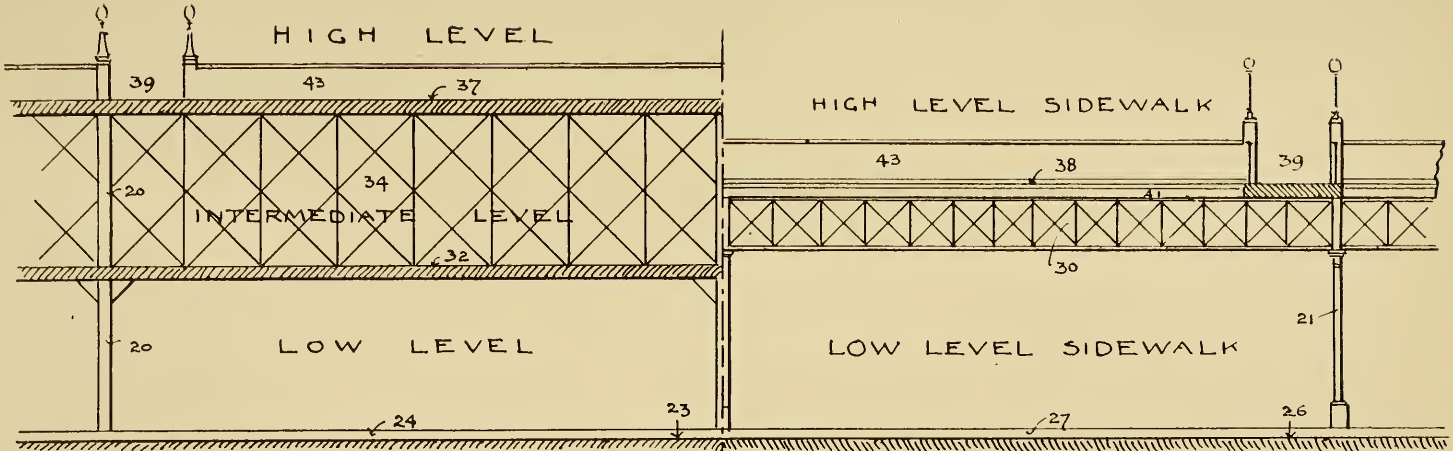


Fig 3

SECTION ALONG CENTRE LINE OF A STREET WHEREIN ELEVATED RAPID TRANSIT R.R IS.(Z)

ELEVATION OF HIGH LEVEL SIDEWALK

Copyrighted by W. J. Cuthbertson - 1900

20. Columns supporting high-level roadway.
21. Columns supporting high-level sidewalk.
23. Local car tracks.
24. Platforms.
26. Roadways for freight.
27. Low-level sidewalk.
30. Trusses supporting sidewalks.
32. Rapid transit elevated tracks.
34. Trusses supporting rapid transit and carriage roads.
37. High-level roadway.
38. High-level sidewalk.
39. Bridges.
41. Gutters of high-level sidewalk.
43. Parapets around light areas.

dangers of a trip through the streets are so familiar that I will but briefly allude to them.

We have a daily roster of peoplc crushed, maimed, ground to pieces or otherwise damaged by the street cars and by other vehicles. In our streets railroad cars fly by in opposite directions, while intermixed therewith are vehicles of all descriptions, some drawn by horses, others driven by man-power and others by gasoline or electricity. It is no wonder that those who are not thoroughly used to this pandemonium can but with difficulty steer themselves amongst these multitudinous moving things, and that even those who are brought up amongst them cannot for a moment relax vigilance without risk of their lives, so that, notwithsanding the regulation of the traffic by the police and other safeguards adopted, accidents to pedestrians attributable to the congested and mixed traffic of the streets are inevitable and frequent.

Accidents to vehicles and their occupants are also frequent. They are attributable to the following classes: Collisions between the cars themselves; between cars and other vehicles (due to the car lines being used by both); collisions among other vehicles (due to congestion of traffic and slow and rapid vehicles using the same road; also to the bad state of the roadbed due to the frequent excavations necessary to get at underground pipes); and collisions with these excavations and the detritus therefrom.

Amongst other classes of accidents are those due to the fall of live electric wires from the overhead lines.

Now let us see how these accidents are practically eliminated by the system under discussion.

As to pedestrians, one on the upper street wishing to cross the road or take a car need not cross the upper road (which is used by fast teams) at all, but may descend the stairs to the low-level intermediate platforms, whence he may take a car or cross the lower road (which is used for slow teaming) to the opposite sidewalk; and then, if he wish, take an elevator to the upper sidewalk. The vehicles on each side of the lower street being allowed to go in one direction only, and the car tracks between the platforms being used by cars only, the danger of crossing is practically *nil.* Fast-traveling automobiles are allowed only on the upper road; freight autos on the lower.

Coming to accidents to the vehicular travel, which are now of almost daily occurrence, no diminution can be expected until the introduction of some such system as that now before you,

by which the heavy drays and slow traffic are kept in the lower street and the car tracks devoted to their own use; the side of the street located on one side of the car tracks being devoted to up traffic and the other side to down traffic.

As to accidents due to the tearing up of the streets, by the adoption of the subway system shown they will be done away with entirely.

Accidents from electricity will be considerably reduced, as the power lines for the electric cars are kept within the space under the high-level roadway occupied by said cars, while the remainder of the street will be clear of all wires, they being carried in the subway.

In regard to underground and elevated railroads, indicated as numbers (1) and (3) on the diagram of the introductory paragraph, there is no doubt the accidents happening on either of these systems are intensified by the facts of one being in the darkness and cramped space of a tube or tunnel and of the other being suspended in the air.

As used in the new system, although the rapid transit railroad is elevated, its height from the normal grade is but moderate, and the subways for the cross-town rapid transit are close to the surface and thoroughly lighted in their whole courses by the sidewalk lights on the platforms of the local car lines above.

2. HEALTH AND RECREATION.

People traveling in underground tunnels cannot arrive at their destination in such fine condition as those who travel in the open air and sunlight, and the constant use of them finally deteriorates health. Now, in the plan herein described, the local and most of the rapid transit lines are above ground and are open to the air and sunlight, giving pure air at the same temperature as the normal air and the recreative effect of looking out upon lively sights and light and shade instead of upon the uninteresting walls of a subway. The discomfort of tubes is too well known to need description, and the heat evolved by the electricity adds to it, and there seems so far no way of mitigating it.

Again, not only to the travelers, but to the workers in stores, the conditions under the new plan will be more favorable to health than under the present. At present, basements are used in connection with many stores by work people who remain there, not only occasionally, but all the time during working hours. These are underground, depending for their light on

the sidewalk lights. In the new plan the ground floor takes the place of a basement, with the benefit of direct light and air from the street. To be sure, the sidewalk above and the upper roadway cut off a part of the light, but the large open spaces in the upper street forming light areas serve to give a bountiful supply of light and fresh air. Then the cellars, which will correspond with the present basements, will be used only for storage.

In the matter of drainage, under the new plan the draining of a city can be done with the minimum of unhealthfulness and disagreeableness, for the sewage is carried in channels open to inspection, which can be kept constantly clean and unobstructed. Also, the sidedrains from the buildings can be cleaned out periodically with but little trouble and expense, there being a movable cover in the sewer at every connection.

With the light and ventilation obtained, a promenade in the subways could be made without meeting anything more disagreeable or unhealthful than during a walk on the surface of the streets now. Loss of life to sewermen by being washed away and drowned or suffocated (of which a case in point has but lately happened in San Francisco and another in London but shortly previous, in which latter case three men were washed away by a flood of storm water and two of them drowned) will be eliminated.

3. ECONOMY, INCLUDING CONVENIENCE.

When the citizen of twenty-five years hence shall look back at the municipal transportation of the commencement of the twentieth century, he will surely be astonished at the great sacrifice of convenience and of time made by the citizen of this epoch, due to its haphazard street plan, and will wonder why conditions so far behind the times could have been tolerated. We will enumerate some of these inconveniences, and will show how they will be abolished or mitigated under the new plan.

Traffic. — The street car tracks are now used by cars and ordinary vehicles in common. This leads to much delay in travel by vehicles breaking down on the tracks and by heavily laden and slow teams getting in front of the cars. This is done away with by the new plan.

Other traffic will also be facilitated. Delays caused by blockades, now so frequent, will be things of the past in consequence of so much of the traffic being carried by the high-level street.

On the surface of the present-day roadway are the manholes and handholes for getting at the sewers, cables of the cable cars, electric wire conduits, etc., so that it is studded with the plates covering these, causing, as wheel traffic rolls over them, an addition to the already deafening noises of the street. Obstructions are caused by the many breakings up of the roadbed necessitated by the lack of a subway, and by building materials required for the erection of new buildings. Under the new plan the latter will be placed on platforms over the light areas of the high-level street, and all the other obstructions, being unnecessary, will be removed from the roadways.

Among other things, the scavenger wagon, the source of so much discomfort to our olfactory nerves, and the keeping on hand quantities of decaying matter until the arrival of said wagon, so deleterious to health, will be abolished, the subway scavenger train before described taking their places.

Promenading. — In consequence of the transaction of all rough work on the low level, the high-level pavement is unencumbered by the many obstructions in the way of the present-day pedestrian: the rolling of barrels from drays into cellars, piles of merchandise waiting to be shipped or in process of shipment, porters with burdens, the rush of messenger boys, newsboys and of car-catchers, sidewalk elevators and trap doors, steps descending into basements, valves of the water-works, fire-plugs, telegraph poles, signs, etc. By the eliminating of all these obstructions a promenade through the streets of the new régime will be agreeable and peaceful and free from all the inconveniences now encountered. Besides, one can promenade in wet weather as well as in dry, for the high-level sidewalks form colonnades below under which people can pass dryshod and dryclothed.

Not only are the inconveniences before mentioned done away with, and their attendant waste, but direct economies are gained by the new system.

Cost. — Underground work being more expensive than work in the open, the first cost of an underground railroad is considerably more than the building an ordinary road overground as shown. Again, making comparison with an elevated railroad, the cost of an overhead carriage road is no more, if as great.

The cost of building an underground railroad in San Francisco will be further increased, in the lower part of the city, by reason of its being below water level and of its excavation being all in sand or soft mud.

Maintenance. — After the subways are built for the pipes, much economy will be gained in the installation of new work and in making repairs, which would require no digging from the street and no disadvantage to the workmen from working in the midst of traffic or in a cramped place. The house drains, for example, go directly into the subway sewer close to the property line, doing away with digging trenches in the streets and laying side sewers, those bugbears of the small property owner under the present régime.

There are also gains in indirect economy by the adoption of the new system, such as eliminating the following:

The interference to traffic caused by work on the surface.

The interference with the shipping of merchandise caused by the congested condition of the streets, the two-tiered streets allowing the freight handling on the lower and the retail selling on the upper level to be carried on without obstruction from other traffic.

The waste of time and patience caused by lack of proper car service.

Expenses and loss of time from impaired health caused by bad sewerage system and other bad conditions and from maimed bodies and burial expenses caused by street accidents.

Damage to business during the building of an underground railroad.

Damage done by the flooding of basements of stores and the consequent destruction of valuable goods by the obstruction of the sewers preventing the sufficiently rapid outlet of storm waters. In the new plan double capacity is obtained by having a sewer on each side of the street, as well as greater facilities for cleaning.

4. ARTISTIC EFFECT.

The opportunities for artistic effect are unquestionably greater in the proposed arrangement. The upper streets, from which are banished the disagreeable sights which are wont to meet us in our present streets, will form vistas unequaled, and every part of them will lend itself to some artistic effect.

The parapets and ornamental railings bounding the roadway and sidewalks, the lines of the bridges connecting the same, and the pedestals at their junctions forming coignes for sculpture and lamps, with occasional recesses for seats from which may be viewed the traffic below, all will form an interesting and picturesque study, as well as a monumental *ensemble*. Opposite

public and important buildings bays will be formed in the upper roadway for waiting vehicles. Municipal regulations as to heights of buildings preventing hideous skyscrapers from marring the skyline will add still more to the beauty of these streets and will allow the life-giving sun to send its rays upon this enchanting scene.

The contrast between the foregoing picture and that of an elevated railroad (both to users of the street and of the windows of the abutting houses), with its darkening of the street below and its rumbling noise, is so strong that comment is unnecessary.

Objections.

Having now compared this two-storied street arrangement with the other street arrangements and pointed out its advantages, it is time to take a glance at the objections that may be raised against it.

First. — An objection, at first sight, is the taking from the property owner the private use of the sub-sidewalk space, although the same really belongs to the public. Any space, however, the property owner may lose is counterbalanced by the extra basement space he gains by the raising of the street to the high level, which saves him the expensive delving into the bowels of the earth which is now so common.

In his cellar he will obtain the same amount of light from the subway as he does now from his sidewalk lights. There is also a saving by having all the service mains close by and handy to his building.

Second. — Objection might be made because of the difficulty experienced in the connection of high and low levels so that vehicles may go from one to the other.

In hilly San Francisco, or in any other hilly city, the occasion of this objection is really a benefit; for as the two-storied roads will be used chiefly on the business streets, which are always the valley streets, a connecting road will run level from the upper road until it strikes the rise of the street below and there becomes merged into it. So that a vehicle traveling on the upper system of roads when it follows the connecting road and reaches the normal or ground level will have saved the traction of raising itself the height of the difference between the high and low levels.

This subject will be exemplified when we consider its particular application to San Francisco.

Third. — Objection to the expense of adapting the present buildings to the new arrangement.

As is the case with the introduction of all new things, there will be some trouble and expense in adapting the present conditions to those appertaining to the new plan. Store fronts will have to be altered and entrances made from the upper sidewalk. This will not be such a great undertaking as it may appear at first sight. All of the large stores already have second-story show windows, which will come in for the new street. In San Francisco, especially, all the modern buildings, except a very few, are yet to be built on Market and other streets. If this system is adopted at once, all new buildings will conform to the appropriate levels and no extra expense will be entailed; the expense of changing those already built will easily be recouped by the benefit of having two stories of show windows accessible from the street or, in other cases, of two stories of street floor offices and by the numerous other accruing benefits previously described. For example, on Montgomery Street, San Francisco, the capacity for street-floor offices will be doubled, with a corresponding increase in rents.

Fourth. — It might be objected that the lower street will be dark.

With the large light wells obtainable on the wider streets, it will assuredly not be so to any extent. In the case of narrow streets the upper sidewalks will be made of prism lights, which will flood the space below with all the light needed.

Application to San Francisco.

We will apply this plan to San Francisco, the city in which we are more particularly interested; firstly, in regard to the street railroad system, and secondly as regards the ordinary carriage road.

It is premised that all the work for these undertakings will be done by the city, and that all the new car lines will be run by the city, which are on the lines of modern ideas.

To elucidate to those who are not familiar with San Francisco points made in this paper, I will state briefly that, outside of flats around the Bayshore, this city consists of hills and valleys. Market Street is the chief street, running diagonally across the city, dividing it into north and south parts. The streets on the north side run into it at about an angle of 45 degrees, while the streets on the south of it in the business part of the city run parallel and at right angles to it.

Rapid Transit Railroads. — The first of these would naturally be the one on Market Street. This line will answer two purposes: below Geary Street to the ferry at the foot of Market Street it will act as a feeder to the new Municipal Geary Street Railroad, so that the latter may have an outlet to the said ferry, and it will give quick service to all those lines running into Market Street on both sides. It will make the people a competitor to some extent of the present street railroad company which now has practically a monopoly of all the street-car traffic.

Other rapid transit roads would be built as wanted; but their routes will have to be decided upon in the first instance, so that the height of the upper carriage road may be regulated to suit.

Surface Railroads. — The present surface railroads will remain as they are, excepting that the motive power will be changed to electricity where practicable. The cars being hidden under the upper street the objection to overhead electric wires will not exist.

The loop at the foot of Market Street will naturally be adopted, but this will be combined with the overhead street and will form a grand peristyle effect in connection with the upper hall of the Ferry building.

The Upper Roadway. — Now let us turn to the upper roadway, used for ordinary traffic.

Starting from the Bay, the main road will follow Market Street to its present end. It will strike the top of the range of hills enclosing Eureka Valley, which will be graded down sufficiently to allow the lower road to keep its level. Then extending Market Street across Eureka Valley, it will be carried on a viaduct to the Corbett Road, into which it will be merged, and will continue around Twin Peaks to the ocean, thus forming a continuous and unobstructed driveway from bay to ocean. At some future time Twin Peaks will be tunneled for a car line and have a cable car running to the park at the top; but the scenic driveway will continue to be the Corbett Road, the parking of which on its low side, so as to allow an unobstructed view of the magnificent panorama, should be done.

From the main artery of Market Street let us take a rapid glance at some of its branches.

On Montgomery Street an upper driveway is an absolute necessity, as is recognized by any one who has witnessed the present continual blockades of that street. This will stop at Telegraph Hill, with spurs on Pine Street and other convenient

streets running to the east slope of "Nob Hill," whence descents will be made to the lower level. This will help out the scheme of Engineer Parsons for the improvement of that slope.

Other streets on which connection with the low level can well be made are Grant Avenue and Golden Gate Avenue, both of which rise enough to allow the spur road to reach them on or about on the level; City Hall Square, where it can be run to the main floor of that building; Van Ness Avenue, where it will be continued out to the new Park Panhandle, in the making of which it will save some cutting and filling.

At Haight Street a spur will be run on to the Haight Street hill and thus descend to Valencia Street and the Mission.

At Dolores Street it will be on a level with that street and also with the new boulevard proposed to run from the junction of Dolores and Market streets to the present Park Panhandle, designed by me some years ago and adopted by the Association for the Improvement and Adornment of San Francisco in its map of the improvement of that city. This boulevard will make a continuous level driveway from bay to park, and through it to the ocean, along the beach to the road before described, around Twin Peaks, thus giving the most varied interurban drive to be found anywhere. Time will not allow me to point out the possibilities of this scheme, which will make of San Francisco the most magnificent city in the world. From this improvement we shall have a direct return at once in carfares on the municipal railroads.

Summary.

Although this is but a rough sketch of the scheme, I believe sufficient has been indicated to allow of a judgment upon its feasibility, and I conclude its description by a summary of its claims.

1. The substitution of light and airy car lines for dark and ill-ventilated tunnels.
2. Covered ways for travel in inclement weather.
3. All the sewers, pipes and wires accessible without tearing up the streets.
4. An unseen and unobjectionable scavenger service.
5. A swift, convenient and safe method of car service.
6. Basement above ground, doing away with underground dark and damp cellars.
7. Two stories of street store fronts.

8. A roadway without car tracks and yet a street with the convenience of car service.

9. Clearance from the promenade of all obstructions due to commerce or otherwise, which are hereby relegated to the lower regions.

10. Economy, both in construction and service.

11. Grander artistic effects than are offered by the ordinary streets, or by any other scheme so far devised.

Conclusion.

Now, as is generally known, California is the country of great things, — material, physical and mental, and possibly psychical, — great in trees, great in physical humanity and great in ideas and inventions. Why not great in civics?

Because we have not relied sufficiently upon ourselves in that case, but have gone to strangers for advice. This shows that Californians are great likewise in modesty. No doubt it is well to hear and see what other places are doing and to receive suggestions from them — sometimes as to what to avoid — but whenever we want to do a thing right we must do it ourselves.

The ideas obtainable from the experience of Chicago. New York and other cities as to the beautification and improvenent of our Californian metropolis are inapplicable to it. It is a city *sui generis*, understood only by its own children, who know and respect most of its idiosyncracies, and therefore the ideas presented here by a Californian are not to be considered unavailable because found unsuitable elsewhere, but deserve full investigation.

As before, San Francisco has surmounted difficulties in its own way; for example, in its introduction of the cable-car system; so will it solve the metropolitan transit problem as successfully.

As generally, so far, California has been in the front rank in great, useful and beautiful things, why should it not inaugurate a great, useful and beautiful system of civic intercommunication?

Note by Author. This paper was read previously to the catastrophe that has visited San Francisco. Some of the remarks are therefore a little out of date. The introduction of the scheme into that city, however, is now much simplified and the arrangement of buildings to suit it can now be made from the ground up with no extra expense.

[Note. Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by October 1, 1906, for publication in a subsequent number of the Journal.]

THE POLLUTION OF THE TIDAL WATERS OF NEW YORK CITY AND VICINITY.

By George A. Soper, Member of the Boston Society of Civil Engineers.

[Read before the Sanitary Section, March 7, 1906.]

The studies which we are about to consider are largely the outcome of a proposal to collect the sewage of a populous community in New Jersey and empty it without purification into the center of New York Bay. The project was that of the Passaic Valley Sewerage Commission and the object was to relieve the Passaic River of the excessive pollution which had made it a public nuisance.

The quantity of sewage which it was proposed to dispose of in this way was ultimately to be 345 830 000 gal. of house and factory waste per 24 hr. This sewage was to be continually discharged at a depth of 40 ft. below the surface of the bay, in the main channel, at a point about three quarters of a mile northeast of Robbin's Reef Light. This point is about the geographical center of the upper bay, or land-locked portion of New York Harbor.

The subject was brought to the attention of the New York Legislature in 1903 and a law was passed on May 11 of that year entitled, "An act to authorize the appointment by the Governor of a commission to investigate certain threatened pollution of the waters of New York Bay and to make an appropriation for the expenses of such commission." The commission was promptly appointed and assumed its duties. It consisted of Daniel Lewis, commissioner of health of the state of New York; Olin H. Landreth, professor of civil engineering, Union College; Myron S. Falk, consulting engineer; Louis L. Tribus, commissioner of public works of the borough of Richmond, New York, and George A. Soper, consulting sanitary engineer.

The first report of the commission was made to Governor Frank Wayland Higgins, March 31, 1905. It was published in the following autumn and is now out of print.

A second and final report will probably be made within a few weeks.* The commission will go out of existence by statute in April, 1906.

The first report of the New York Bay Pollution Commission

* The second and final report was submitted April, 1906.

made objection to the project of the Passaic Valley Sewerage Commission and, in fact, to the present policy of the unrestricted emptying of crude sewage into the tidal waters in the vicinity of the metropolis wherever that policy was followed. New York City was regarded as the principal offender, as matters stood. To that municipality, most of the sewage pollution of the bay and neighboring waters was due. Sewers as large, if not larger, than those contemplated by the Passaic Valley Sewerage Commission were under construction and in contemplation by New York City, and if this method of disposal was not prohibited, it seemed only a question of time when a nuisance as great if not greater than that which would probably result from the New Jersey project would be produced. How to dispose of sewage in the future in the vicinity of New York was considered a very serious problem and one upon whose early and proper solution depended the welfare of all the communities in this vicinity. It was desirable that the question should be studied exhaustively. The commission recommended that the two states of New Jersey and New York should appoint metropolitan sewerage commissions which should act together in investigating the best means of exercising proper control over sewerage questions in this vicinity in the future.

In the following paper, no attempt will be made to present a brief against the state of New Jersey or any part of it. This would be unnecessary even if my inclination suggested it. The Court of Errors and Appeals of New Jersey on March 6, 1905, declared unconstitutional the act under which the Passaic Valley Sewerage Commission proceeded, because of the method provided for levying taxes to meet the cost of construction and maintenance. The difficulty so presented has not yet been overcome. Furthermore, by an old and tested agreement with the state of New Jersey, the state of New York has jurisdiction over the waters of the whole bay for police and sanitary purposes and could exercise this right of protection if it was thought desirable to do so.

My object is to invite you to consider the interests of the Metropolitan District as a whole, without respect to state or municipal boundaries and to discuss the following problem from a strictly sanitary standpoint: Has or has not the time arrived when considerations of future economy, no less than the interests of public health and comfort, require that a comprehensive plan or policy be adopted for future sewage disposal for the New York Metropolitan District?

Geography and Other Peculiarities of the New York Metropolitan District.

A glance at a map of New York and vicinity shows that it is peculiarly situated with respect to its adjacent tidal waters. Considering a circle with a radius of twenty miles, which just includes the extreme northern and southern limits of the city, it is seen that about one third of the surface is water and two thirds land. Bays, straits and rivers intersect it in every direction. New York City alone has 444 miles of water front. The center of this circle is the center of densest population. Here the water courses seem to come to a focus like spokes at the hub of a wheel. There are acres of tenements on Manhattan Island near this center, where there are over a thousand people to the acre. If the rest of New York City were as thickly populated, it would contain more than the combined population of the United States, France, Germany and European Russia.

The actual population, as given recently by the Census Bureau of the United States Department of Commerce and Labor and the Secretary of State of New York, is as follows:

New York City	4 014 304

Within a circle of twenty miles radius of the New York City Hall, in 1905:

New York State	4 174 392
New Jersey	1 250 311
Total	5 424 703

The increase in population has been very rapid, as is well shown by the following data which cover the same area as the present city of New York:

Population in 1790	49 401			
1850	696 115	— an increase of	1 309.1	per cent.
1890	2 507 414	— an increase of	260	per cent.
1900	3 437 202	— an increase of	37.1	per cent.
1905	5 014 304	— an increase of	16.8	per cent.

The rate of increase in the Metropolitan District as a whole, has been 17% in the last five years. At this rate the population will be more than 10 000 000 in 1930.

The tidal waters of New York are not only great highways of commerce but they play an ever increasing part in the life, health and pleasures of the people. An unpleasant odor from

the waters, even if noticeable only for a few hundred feet, would be inadmissible.

It is interesting to consider how intimately the life of the city is associated with its tidal waters.

The city has 7 325 260 acres of parks, a large number of which are on the water front. Riverside Drive is on the bank of the Hudson, the Speedway runs along the Harlem River, the Bay Ridge Parkway follows the shore of the upper bay and the Hudson County Boulevard, in New Jersey, skirts the crest of the Palisades.

On all festival occasions the city turns naturally to the Hudson and to the bay as to a great water park. These waters are the chosen place for the nation's greatest naval pageants. They are the home of a thousand pleasure boats from the palatial yacht of the multi-millionaire to the diminutive canoe.

To the poor of the city, the docks, and particularly those of the North and East rivers, are a place of welcome refuge in the hot nights of summer. For the accommodation of persons who cannot go to bathing beaches, or on other excursions across the harbor, the city has built recreation piers upon the water fronts of Manhattan and Brooklyn. The number of persons who visit these piers is surprisingly large. At a single one of them on the east side of the city, 8 000 entrances have been counted during a single evening.

Swimming baths float in the waters of the North and East rivers on the Manhattan and Brooklyn shores and accommodate upward of 3 500 000 bathers per season. At least one large inland swimming pool is supplied with water pumped from the bay.

A floating hospital carries 1 500 persons per day down the bay during summer weather and provides 7 000 baths supplied with water pumped directly from the harbor.

Within a few years floating hotels have made their appearance.

The use of salt water for fire service has been decided on to protect property against conflagration. By this plan pumping stations and separate systems of pipes will be constructed. To guard against corrosion, the pipes will be filled with fresh water when not needed. For fire purposes water from the bay and rivers will be pumped into them. One such plant has already been built at Coney Island. The others are about to be contracted for.

At present the sewage of the Metropolitan District is, for

the most part, disposed of in the crudest manner possible. It is emptied into the tidal waters without screening or other purification and at the nearest point which seems unlikely to produce a local nuisance. On Manhattan Island it was formerly customary to empty the sewers at the bulkhead lines, but this caused such offenses to sight and smell that the outfalls are now usually carried nearly to the outer ends of the piers. They usually empty at about the elevation of mean low water. In other parts of the water front the sewers generally empty at the bulkhead line.

In a number of instances this method of sewage disposal has led to serious difficulty. In a tributary stream of the East River, called Newtown Creek, odors from factory and household waste became so prevalent and offensive some years ago, that the state legislature was compelled to enact laws to restrict further contamination of this kind. The Gowanus Canal, in Brooklyn, is at present notorious for its stench. A tunnel has recently been contracted for at a cost of about $715 000 to carry water into the head of this canal from the bay. Pumps for this purpose will probably cost about $50 000 additional. The waters of parts of the East River and Kill von Kull are frequently covered with oily sleek which is offensive to both sight and smell. A number of sewage disposal plants intended to purify the sewage of small sections of the city in the outlying districts have been built, but usually with poor results.

The total amount of sewage which now enters the bay and tidal waters in the vicinity of New York has been estimated at 455 000 000 gal. per day.

Bacterial Condition of the Water.

In the autumn of 1904 samples of water were taken from various points in New York Bay for bacterial and chemical analysis. About fifty samples in all were collected at points between the south end of Manhattan Island and Coney Island on the one hand and between the south end of Manhattan Island and Raritan Bay on the other. The colon bacillus was nearly always found, according to the presumptive test. There was a progressive reduction in the numbers of bacteria from Manhattan Island toward the ocean. The largest number which developed in gelatin was 50 000 and the smallest about 2 000.

The following table gives the average numbers of bacteria per cubic centimeter found in different parts of New York Bay.

TABLE SHOWING NUMBERS OF BACTERIA PER CUBIC CENTIMETER IN THE WATER OF NEW YORK BAY, OCTOBER, 1904.

Upper Bay, Middle of	21 000
Upper Bay, Staten Island Shore	17 000
Narrows	10 000
Lower Bay, Gravesend Bay	7 000
Lower Bay, off Coney Island	4 000
Lower Bay, off Staten Island shore	2 000
Mouth of Raritan River and Arthur Kill	50 000

Most of the samples of water were taken to the Mount Prospect Laboratory, Brooklyn, and were analyzed, as a rule, within two hours of the time of collection. In the presumptive tests for coli, specimens of water 0.1 cu. cm., 1 cu. cm. and 10 cu. cm. were used. This work was done under the supervision of Mr. Daniel D. Jackson. In order to obtain a check on the results, some samples were sent to the Bender Hygienic Laboratory, Albany, N. Y., where they were examined under the supervision of Dr. R. M. Pearce.

In interpreting the results a positive presumptive test in each of the three samples was taken to indicate pollution; a negative result with 0.1 and a positive result with 1 and 10 was taken to be probable evidence of pollution; a negative result with 0.1 and 1 but a positive result with 10 was not regarded as sufficiently conclusive to warrant any opinion.

BACTERIAL CONDITION OF SHELLFISH.

As will be more fully explained beyond, the cultivation of oysters and clams is carried on extensively in the waters of New York Bay. Most of the oysters are taken from the southeast shore of Staten Island, but some shellfish, and especially clams, are grown in that portion of the lower harbor known as Gravesend Bay. Specimens of both kinds of shellfish were collected and examined by the presumptive test. They were opened with a sterilized knife and the liquid which was contained in their shells removed in portions of 0.1 cu. cm., 1 cu. cm. and 10 cu. cm. and mixed with fermentation broth in Smith tubes. The laboratory process was thereafter similar to that followed in the examinations of water. This method was not the most searching which might have been employed, for it did not detect bacteria which may have existed in the gills and alimentary tracts of the shellfish, but the results were considered sufficiently instructive. In general terms, the results supported the belief

that shellfish taken from polluted waters are themselves polluted and, conversely, that shellfish which have been grown in pure waters are uncontaminated. Yet the samples examined in this study did not always bear as much evidence of pollution as might be expected.

The oyster beds on the Staten Island shore lie between, but at considerable distances from, two great sources of danger, one the polluted water of the upper bay and the other the contaminated water from the mouth of the Raritan River and the Arthur Kill. The oysters which were freest from contamination came from the vicinity of Great Kills on the Staten Island shore and Swash Channel, points which are well removed from local sources of pollution and apparently beyond the reach of injurious matters from the cities. The oysters which were "drunk" or "fattened" in fresh water creeks always bore evidence of contamination.

Chemical Condition of Water.

The chemical analyses which were made by the New York Bay Pollution Commission show that New York Harbor bears chemical evidence, both at ebb and flood tides, of pollution, especially the upper bay. The information at hand does not warrant the opinion that the water is everywhere and at all times badly contaminated, but the chemical evidence well supports the bacterial results in showing that traces of pollution can be found after the sewage has been allowed to commingle with the waters of the bay and traveled miles from its points of origin.

One of the most useful measures of pollution was the determination of nitrogen in the forms of free and albuminoid ammonia. The results of these chemical analyses were compared with results of examinations of uncontaminated sea water, drinking water and sewage, taken from Mr. H. W. Clark's report in the report of the Metropolitan Sewerage Commission upon a High Level Sewer for the Relief of the Charles and Neponset River Valleys, Boston, Mass., 1899, p. 91; the report by Mr. G. C. Whipple contained in the report of the Commission on an Additional Water Supply for the City of New York, 1903, p. 520; and the report of Mr. H. W. Clark contained in the report of the Committee on the Charles River Dam, Boston, 1903, p. 221. From these sources the following table was prepared:

TABLE SHOWING THE AMOUNT OF FREE AND ALBUMINOID AMMONIA IN SEA WATER, DRINKING WATER AND SEWAGE.

Point of Collection.	Date.	Free Ammonia.	Albuminoid Ammonia.
Sea water		0.057	0.124
Quincy Bay, Mass.		0.056	0.124
Atlantic Ocean, 3 miles south-east of Sandy Hook Light-ship	Feb. 27, 1903	0.064	0.076
Off Boston Lightship	Nov. 11, 1902	0.012	0.068
Sewage		45.4	7.5
Good drinking water as high as,		0.013	0.16
Hudson River at Poughkeepsie,		0.020	0.137

The studies of the New York Bay Pollution Commission show that the surface water of New York Bay contained at the time of examination about $2\frac{1}{4}$ times as much free ammonia and about $1\frac{1}{6}$ times as much albuminoid ammonia as sea water. It also had about $6\frac{1}{2}$ times as much free ammonia, but about the same amount of albuminoid ammonia as the Hudson River at Poughkeepsie. The samples were all taken near the surface.

The most polluted samples were taken near the Battery, the middle of the upper bay, the Narrows and near Coney Island.

By putting the figures into condensed form the following table has been prepared:

TABLE SHOWING THE AMOUNT OF FREE AMMONIA AND ALBUMINOID AMMONIA, IN PARTS PER MILLION, IN SEA WATER, HUDSON RIVER WATER AND THE WATER OF NEW YORK BAY.

Point of Collection.	Free Ammonia.	Albuminoid Ammonia.
Upper Bay	0.130	0.183—0.162—0.188
Narrows	0.120	0.120
Lower Bay	0.103	0.118
Sea Water	0.012	0.068
Hudson River at Poughkeepsie	0.020	0.137
Sewage	45.4	7.5

THE EFFECTS OF TIDES, CURRENTS AND OTHER PURIFYING AGENCIES.

One of the surprising results of this investigation, as disclosed up to this point, was the fact that the tide had little

visible effect in eliminating the evidence of pollution. It had always been assumed that the sewage and other organic matters which were emptied into the harbor were immediately carried away by vast quantities of pure water which came from the sea, Long Island Sound and the Hudson River. But it was apparently found by the New York Bay Pollution Commission that there was not a great deal of difference between the quality of the water of the incoming and outgoing tides. In some cases the currents which flowed up the bay from the sea were more polluted than those which passed out. Apparently, in spite of the great tidal movement, particles of sewage which were not destroyed passed back and forth indefinitely in the bay and rivers in the neighborhood of their points of origin. The action of the tide seemed rather to cause a diffusion and distribution of the material than a mechanical and permanent removal of it. More light is needed as to the quality of the water, the action of currents and the flow of tides before this subject can be regarded as clearly understood.

The completeness of the diffusion which takes place apparently depends largely upon the swiftness and direction of the currents into which the sewage is discharged, the force and direction of the wind, the stage of the tide and the season of the year. As had been found at Boston, it seemed improbable that the sewage mixed with the water at all depths. It was more probable that it flowed about largely upon the surface.

The most reliable information which could be obtained from government sources as to the tidal discharge of New York Bay and fresh water discharge of the Hudson River was neither full nor accurate. The discharge of the Hudson seems not to have been estimated since the records given by the United States Coast Survey in its reports of 1858–1872. The following data are contained in these reports.

TABLE SHOWING THE DISCHARGE OF THE HUDSON ACCORDING TO UNITED STATES COAST SURVEY REPORTS.

According to United States Coast Survey Report of 1858:	
Close of wet season — (June)	6 038 million cu. ft. per tide
Close of dry season — (Sept.)	3 360 million cu. ft. per tide
Mean	4 699 million cu. ft. per tide
According to United States Coast Survey Report of 1872	4 511 million cu. ft. per tide
Tidal prism of bay, etc	5 330 million cu. ft. per tide
Average discharge of Hudson	5 000 million cu. ft. per tide
Total seaward flow, *average*	10 330 million cu. ft. per tide

The tidal discharge of the East River, Hudson River, Kill von Kull and Narrows, according to the United States Coast and Geodetic Survey Report for 1886, is as follows:

TABLE SHOWING TIDAL DISCHARGES IN THE VICINITY OF NEW YORK, ACCORDING TO UNITED STATES COAST AND GEODETIC SURVEY.

Tidal Discharge per 24 Hours, June 25, 1886.

	Million cu. ft. per 24 hours
East River:	
Ebb (westerly)	8 909
Flood (easterly)	8 014
Excess of ebb	895
Hudson River (at Thirty-ninth Street):	
Ebb (south)	13 993
Flood (north)	12 451
Excess of ebb	1 542
Kill von Kull (West New Brighton):	
Ebb (toward harbor)	3 580
Flood	3 424
Excess of ebb	156
Narrows:	
Ebb (seaward)	27 639
Flood	25 407
Excess of ebb	2 232
Tidal prism of bay, etc., million cu. ft.	5 000

The question of the diffusion of the water of the bay has such an important bearing on the question of the disposal of the sewage which enters it that I have thought it worth while to collect some data to show the proportions of sea water and fresh water in the bay under different circumstances.

PROPORTIONS OF SALT AND FRESH WATER IN NEW YORK BAY.

The commingling of the salt and fresh water is best indicated by the records of analyses of samples of the water taken at various points in and about the harbor. For the purpose of this study the water of the ocean beyond the range of fresh water influence is assumed to have an average of about 18 000 parts of chlorine per million, although it varies considerably in different parts of the sea and is probably not always the same in the

vicinity of New York. We may take the chlorine of Long Island Sound to be about 14 000, and of the Hudson at Poughkeepsie at about 1.5 parts per million.

From these studies it is evident that the water of New York Bay is not composed of fresh and sea water in any fixed proportion. It changes with the weather and with the season. In the lower bay it has been found to range from about 20 per cent. to 100 per cent. sea water, according to the location of the point with reference to local sources of dilution and the amount of fresh water coming down the various large rivers. A fair average for the lower bay, under ordinary conditions of weather and beyond the range of local dilution, is difficult to decide on. It is not, improbably, about 75 per cent.

The water of the Narrows has been found to vary from 43 per cent. to 77 per cent. sea water, the majority of samples averaging about 65 per cent. At the Battery the samples have ranged from 15 per cent. to 69 per cent. sea water, with an average, under what appear to be normal conditions, of about 45 per cent.

The lower Hudson is the scene of the widest variation in the proportions of sea and fresh water. In the foregoing tables it is seen that the Hudson at Spuytėn Duyvil has ranged from an hourly average of 0.5 per cent. to 44 per cent. sea water for a whole day. There may be as much sea water sometimes at Croton Point as there is at other times at the Battery, 33 miles nearer the ocean. In fact, the upper limit of brackish water may be anywhere between Yonkers and Poughkeepsie. All of the figures given relate to surface conditions of water.

The cause of these differences is to be found in the rainfall, for this furnishes the fresh water which tempers the sea water. In the spring, when the discharge of the Hudson River is at its height, large quantities of fresh water force the sea water out farther and farther toward the ocean. In the late summer, when the rainfall is slight, and in winter when the tributary streams are frozen, the sea water creeps up the Hudson to a great distance. Between Yonkers and West Point the sea water is ever advancing and retreating. Every tide and wind affects it and every storm has an appreciable effect on it.

The Phenomenon of the Underrun.

So far, we have considered only the quality of the water near the surface. There is reason to believe that the condition of the water at the bottom is somewhat different from that at

the top. Owing to its greater mineral content, the water of the sea is about $2\frac{1}{2}$ per cent. heavier than fresh water. This difference tends to keep the fresh water and salt water apart. The sea water seeks the bottom and the river water the top of the bay and river.

The character of the water far below the surface is of interest in this investigation for the reason that sea water tends to precipitate sewage, causing a part of its solid ingredients to settle toward the bottom. Here the water is not so capable of disposing of the sewage as inoffensively as at the surface, because it cannot so readily renew its supply of oxygen.

It will be seen from these studies that the inflow and outflow of the water of New York Bay is not regular, but subject to a range of conditions which make flushing action uncertain and irregular. At times of abundant rain the lower Hudson appears to be well flushed out, but during dry periods sea water, and possibly sewage, flow far inland.

Observations begun in 1858 show that there is sometimes a layer of distinctly salt water beneath the brackish water in the Hudson for many miles above New York. Some persons believe that there are pockets and potholes in the bottom of the channel in which salt water and sewage accumulate. Here the sewage is thought to remain until a heavy rainfall causes a sufficient rush of water down the Hudson to clear them out. This bottom current is called the "underrun."

The underrun of salt water may be, and usually is, quite independent of surface currents. In fact, it is often directly opposed to them. In such a deep river as the Hudson, it is not difficult to imagine opposite currents one above the other, flowing at the same time. At a gaging station established by the United States Government in 1858 between Bedloe's (now Liberty) Island and Governor's Island in the upper bay, the velocity of the underrun moving up the river was found to exceed the velocity of the surface current moving toward the sea. The daily progress of the underrun was 21 miles, at a depth of 68 ft.

It would appear from this and from the fact that the surface water becomes more and more salt at points up the Hudson during dry weather, that the net result of the backward and forward movement of the tides may sometimes be to carry sewage up the river, and not out to sea, as is commonly supposed.

The following extract from the report of Prof. Henry Mitchell, contained in Appendix 15 of the Report of the United

States Coast and Geodetic Survey for 1887, page 308, gives the opinion of a well-known government observer on the sanitary significance of the underrun.

"It would seem that the drainage of New York City must be storing up in August and September at the bottom of the Hudson. Some simple tests for sulphides which we employed when the underrun was first discovered indicated that the mixture of sea and river water was recent. No 'spoiled' water in the potholes of the great central channel was found. Happily for the communities along the lower Hudson, the floods and freshets occur often enough to purge the great trench above New York City of sea water and sewer water in spite of the long inland journeys which these are prone to take in late summer and autumn, and perhaps winter."

Capacity of the Water of the Harbor to Digest Sewage.

If the conclusions of the New York Bay Pollution Commission are correct, the sewage which enters the bay is not disposed of by being carried to sea in a simple mechanical manner, but is more probably assimilated or digested by the water of the bay itself. This assimilating process is one of liquefaction and oxidation in which bacteria play an important part.

Experience and experiments have shown that the digestive capacity of a water for sewage depends largely upon the supply of oxygen which the water contains. If a sufficient supply is not available, the sewage putrefies, giving off offensive odors.

Compared with fresh water streams or the ocean, the conditions in New York Bay are not favorable for the disposal of sewage by assimilation. The constantly changing proportions of sea water are opposed to the existence of a permanent fauna and flora, and the phenomenon of the underrun shows that there is an absence of the vertical currents which are necessary for a continued supply of oxygen to the lower depths where the precipitating properties of the salt water probably carry some of the sewage.

The amount of sewage which can safely be discharged into fresh water is not a measure of the amount which sea water can dispose of satisfactorily. The digestive capacity of salt water is much less than that of fresh. Experiments carried on by Harry W. Clark for the Committee on the Charles River Dam, show that sea water normally holds less oxygen than fresh water, and that putrefaction, with the production of the exceedingly offensive gas, sulphureted hydrogen, is likely to occur when

sewage is mixed with sea water which has not a sufficient supply of oxygen to enable the aërobic bacteria to carry on their work.

The sewage which now flows into the bay enters it in a favorable manner, that is, in comparatively small amounts and at a great number of points. This aids in its general diffusion, without which no effective purification could take place.

It is impossible to say how much sewage could be discharged into New York Bay without overloading it, that is, causing its supply of oxygen to become exhausted. Should such exhaustion occur, offensive putrefaction would result, with the production of foul odors. Already there are certain localities where the water is decidedly offensive to the sight and smell. Where, however, the tidal currents are sufficient to promptly carry the impurities to the main channels and there disperse them, there is, as yet, no trouble.

The amount of organic matter discharged into the rivers and bay in the vicinity of New York is not known with exactness, but it can be approximately determined from estimates of the amounts of sewage discharged and the rainfall. The quantity of sewage discharged into the tidal waters in the neighborhood of New York has been found to be now, in 1906, about 455 000 000 gal. per 24 hr., and the amount of drainage due to rainfall, estimated on the basis of 42 in. of rain per year and a runoff of 75 per cent. over an area of about 162 miles, is about 243 000 000 gal. These together make a total of 698 000 000 gal. of drainage wastes which the rivers and harbor receive daily.

There are no data to show the composition of this drainage. If its composition is similar to that of Worcester, Mass., the only American city whose mixed house and street sewage has been analyzed, there are 1½ tons of solid, dry sludge for every million gallons, or 1 047 tons in all. Of this, about one half is probably organic matter and capable of putrefaction.

Considered as a whole, there are no indications that the bay is now being taxed beyond its capacity nor that it cannot digest considerably larger quantities of sewage, provided they are added properly, that is, through a sufficient number of outlets sufficiently far apart. What would happen if a very large amount of sewage were to be discharged at a single point is not ascertainable. There is reason to believe that it would not be disposed of without the production of offensive odors and other conditions which would be intolerable. The chief danger lies in the possibility that the sewage would not mix promptly with the water with which it should be diluted, in which event it

might be carried to inhabited shores, creep up the Hudson with tidal currents or the underrun, or rise to the surface and there form an unpleasant, discolored area, as may often be seen in neglected tidal harbors.

In considering the capacity of the bay to digest sewage, careful account should be taken of the increase of pollution to which it is likely to be subject as a result of future increase of population of New York City and the municipalities on these shores. Taking the estimates of Mr. John R. Freeman, who has given close attention to the subject of the future population of New York and its vicinity in connection with his studies of the future water supply of New York, and correcting them by more recent census returns, it appears that the population of this area will be about double that of the present population in the year 1930. If the amount of sewage increases in proportion to the population, and the rainfall remains constant, the total increase in the amount of drainage entering the waters about New York will be nearly doubled by 1930.

Industries Affected by Pollution.

The industries of New York Bay which would be endangered by an excessive pollution of these tidal waters may be classified as follows:

(*a*) Shad fisheries; (*b*) shellfish industries; (*c*) passenger and transportation business; (*d*) excursion and bathing beach enterprises.

These will now be considered separately:

Shad Fisheries.

The shad fishing industry depends upon the annual migration of the shad, *Clupia sapidissima*, from the sea up the Hudson River to spawn. The most important localities for shad fishing are in Westchester, Dutchess and Columbia counties, beside which the catch in the immediate vicinity of New York, by citizens of that state, is insignificant.

It is said that shad have been caught near the entrance to the Kill von Kull which have, when eaten, been strongly suggestive of kerosene, and that the discharge of petroleum refuse was the cause of their unpleasant taste.

The following statistics of the shad industry in the vicinity of New York Bay are taken from a report of the United States Commission of Fish and Fisheries for 1902, page 449.

TABLE 7. YIELD OF SHAD IN THE VICINITY OF NEW YORK BAY CREDITED TO CITIZENS OF NEW YORK STATE IN 1901.

County.	Pounds of Fish.	Value.
New York	3 600	$250
Kings	45 975	2 715
Richmond	118 700	6 360
Total	168 275	$9 325

The yield credited to citizens of New Jersey was valued at $61 508.

When it is considered that the shad industry of New York State yielded in 1901, 3 432 472 lb. of fish, valued at $110 682, and was greater in that year than in any year since 1888, it does not seem likely that the growing pollution of the New York Bay has as yet done material injury to the industry as a whole. It is true, however, that the catches of more recent years have been much smaller than that of 1901.

Shellfish Industries.

The upper part of New York Bay once contained extensive oyster beds. They extended from Staten Island to above Newburgh. Bedloe's Island, now called Liberty Island, was known as Oyster Island, and two reefs which lie to the south of it were called the Little Oyster Islands. Oysters grew there naturally and abundantly without planting. In fact, the oysters were so plentiful that the public was allowed to gather them with little or no restriction, with the result which has so often followed this open-handed policy. To-day these extensive grounds have become exhausted. I have not found that the pollution of the bay has affected the growth. At the present time the cultivation of oysters in the bay is carried on almost exclusively below the Narrows. The Jersey Flats still furnish a small amount of natural seed and a few grossly polluted market oysters are taken there. Attempts to raise seed in the vicinity of Piermont, just above the Palisades, recently, resulted in failure.

The value of the oyster beds in New York Bay below the Narrows is very large. The principal grounds are owned by the state, on the southeast shore of Staten Island, and are let out at a nominal rental to those who apply for the privilege of cultivating them. Nearly the whole shore, from a point near the mouth of the Raritan River to the neighborhood of Hoffman

Island, is now under cultivation. The total area of the beds is estimated at about 30 sq. miles. Prominent oystermen have estimated the yield from these grounds at 500 000 bu. per annum, the Bureau of Shell Fisheries of the Forest, Fish and Game Commission of New York State has estimated it at more than four times this and the United States Commission of Fish and Fisheries has estimated it at about 300 000 bu. for 1901. The value of the oysters is commonly estimated at $1 per bu., although they sometimes bring a much higher price.

Table 8. Extent of the Oyster and Clam Fisheries of Richmond County, N. Y., in 1901, as given by the United States Commission of Fish and Fisheries.

Items.	Number.	Value.
Persons:		
On vessels fishing	170	
On vessels transporting	120	
In shore or boat fisheries	259	
Shoremen	16	
Total	565	
Vessels fishing	36	$88 900
Tonnage	477	
Outfit		29 387
Vessels transporting	50	48 850
Tonnage	619	
Outfit		11 847
Boats	349	42 645
Apparatus — vessel fisheries:		
Dredges	128	6 205
Tongs	40	323
Rakes	18	144
Apparatus — shore fisheries:		
Dredges	6	150
Tongs	318	2 569
Rakes	375	3 159
Shares and accessory property		17 885
Total investment		$252 064
Product Taken.	**Bushels.**	**Value.**
Clams, hard, public reefs	21 900	$18 485
Oysters, market, private areas	291 841	273 617
Oysters, seed, public reefs	8 100	3 430
Oysters, seed, private areas	6 000	3 000
Total products	327 841	$298 532

Some hard clams, or quahogs, are taken in the same locality. The only available estimate of the quantity of the clams is that

given by the United States Commission of Fish and Fisheries, which places the annual output at 21 900 bu.

Table 8 gives details of the oyster and clam business in this region as supplied by government authorities.

The shellfish industries in this vicinity credited to citizens of New Jersey are considerable. The value of the products, as given by the United States Commission of Fish and Fisheries, for 1901 was $680 854. The foregoing table does not represent the whole produce of shellfish from New York Bay. There are small oyster grounds and clam beds in Gravesend Bay, within the limits of New York City. Other localities where shellfish are taken in the vicinity of New York Bay, are Newark Bay, Raritan River, the bend of the Horseshoe, and the mouth of the Shrewsbury River. There are extensive natural seed beds in the Arthur Kill.

The analyses of the New York Bay Pollution Commission show that most of the oysters grown in the lower bay are not polluted, but that those which are taken from contaminated water are practically certain to be contaminated themselves.

The oysters taken from the Staten Island beds are not always shipped direct to market, but are first taken to some convenient stream of fresh or brackish water and there allowed to remain from high to low tide. In this way the size of the oysters is greatly increased. Not infrequently the oyster absorbs bacterial poisons from the water. Some of these "drinking" places, as they are called, in the vicinity of New York Bay are among the most dangerous to be found anywhere. One stream, known as Lemon Creek, on the southeast side of Staten Island, drains a populated area of 2 010 acres and has numerous privies and other sources of pollution on its banks. Topographical inspections and analyses of samples of water and oysters taken from the mouth of this stream have shown that the oysters are grossly polluted. Another and, if possible, more dangerous "drinking" ground is situated at Tompkinsville, Staten Island. This stream flows from a thickly populated area of 2 960 acres. The sewage which is discharged into the Kill von Kull on both sides of this place, within a distance of three miles, exceeds 7 000 000 gal. per 24 hr. During the oyster season 10 000 bu. of oysters are often treated here per day. Sloops come, not only from the neighborhood of New York, but often from very distant points, to "drink" their oysters at Tompkinsville before offering them for sale at the city markets. The "drinking" should be forbidden by law.

Passenger Transportation Business.

The business of transporting passengers across the bay is already large and is constantly increasing. The majority of the passengers are commuters who do business in one part of the city and live in another, or in the country, and go back and forth every day on the boats of the ferry companies.

The pollution of the bay, if unrestrained, might affect the business of these companies in two ways: The number of passengers would decrease if public health were endangered by the trip, or if the water became markedly offensive to the sight and smell.

A more detailed idea of the extent of the transportation business in the waters about New York may be understood from the following table which has been compiled from data courteously supplied by the United States Steamboat Inspection Service.

TABLE 9. NUMBER OF PASSENGERS CARRIED BY THE PRINCIPAL FERRIES IN THE VICINITY OF NEW YORK IN 1903.

Name of Ferry Company.	Number of Passengers.	Route Across.
Brooklyn Ferry Company..	39 911 317	East River.
Hoboken Ferry Company..	32 000 000	Hudson River.
Union Ferry Company.....	30 687 096	East River.
Penn. R. R. Company.....	30 337 493	Hudson River.
Erie R. R. Ferries.........	16 667 252	Hudson River.
L. I. R. R. Ferries.........	15 639 250	East River.
C. R. R. of New Jersey Ferries...............	10 700 862	Hudson River — New York Bay.
S. I. R. T. Ferry...........	7 929 000	New York Bay.
W. S. R. R. Ferries........	5 873 886	Hudson River.
N.Y. and E. R. Company..	4 309 700	East River.
Nassau Ferry Company....	2 680 000	East River.
N. Y. & S. Brooklyn Ferry Company..............	1 720 000	East River and New York Bay.
Fort Lee Ferry............	1 705 659	Hudson River.
Total................	194 161 515	

Of the total number of passengers shown in Table 9, about 8 811 000 traveled directly across the center of upper New York Bay.

Excursions and Bathing Beaches.

For about six months of the year excursion steamers ply about the bay and carry large numbers of passengers in search of pleasure and health. Most of these steamers have fixed desti-

nations, such as picnic grounds and bathing beaches, but some merely sail about without landing their passengers. The total number of passengers carried by excursion steamers in the New York district in 1905 was about 2 300 000. It is obvious that a condition of the water which would be capable of injuring the business of transporting commuting passengers would be certain to do at least equal injury to the excursion business.

A large proportion of the people who patronize the excursion steamers do so in order that they may reach in a pleasant and expeditious manner what are called "day pleasure resorts." These are often, in reality, extensive bathing beaches with hotels, restaurants and a great variety of amusements. The largest day pleasure resort near New York is Coney Island; others are Midland Beach and South Beach, on the Staten Island shore. These are all located in the lower bay, somewhat beyond the Narrows. Millions of dollars have been invested at these resorts to attract visitors, and the places are deservedly popular. They would suffer material loss in patronage if the water became sufficiently polluted to be offensive.

Bathing is far more common in the upper bay than is generally supposed. In the year 1903 over 3 000 000 baths were taken in the floating bath houses maintained by the city of New York on the water front. The number of baths taken in the last two years has not been ascertainable.

Conclusions.

The studies which have been outlined in the foregoing pages lead the New York Bay Pollution Committee to certain definite conclusions which may be briefly summarized as follows:

(1) The effects of the present pollution of New York Bay, although not great, are nevertheless measurable.

(2) A careful study of the proportions of sea water and fresh water in the bay and rivers about New York shows that the sewage of New York City is not promptly flushed out to sea, except during freshets in the Hudson.

(3) The water of the incoming tide is not ordinarily much purer than the water of the outgoing tide in the upper bay and Hudson River.

(4) It is probable that most of the sewage which enters the bay is disposed of in the bay by animals and plants, chiefly the bacteria which live in the water.

(5) The most useful effect of the tide is its production of currents whereby the sewage becomes mixed and diffused.

(6) The drainage which now enters the bay does so in a favorable manner for diffusion; that is, from a large number of outlets situated along an extensive shore line.

(7) How much sewage and other organic matter can be emptied into the bay without killing those forms of life which now destroy it, and so creating a general nuisance, it is impossible to say. This is a matter of great importance, but its proper study requires analyses and experiments which were beyond the reach of the New York Bay Pollution Commission.

(8) Compared with fresh water streams or the ocean, New York Bay is not a favorable place for the inoffensive disposal of sewage.

(9) Should the bay become overloaded with sewage the odors which will arise from it will be particularly offensive.

(10) The total amount of solid matter which now enters the bay with house and street sewage every 24 hr. is approximately equivalent to 1 047 tons of dry sludge. About one half of this is organic matter.

(11) Long before a general nuisance is produced, local nuisances will occur, as may be seen at present where sewers and drainage from industrial works empty into still, or comparatively still, water.

(12) Observations made by the United States Government show that a distinct current of salt water sometimes runs up the Hudson under the fresher water, without respect to surface currents, and it has been suggested that this underrun carries sewage from New York City up the river and empties it into potholes or depressions in the bed of the channel, where it remains until washed out by freshets.

(13) The oyster beds in New York Bay are almost exclusively located on the southeast side of Staten Island and Gravesend Bay.

(14) Most of the oyster and clam beds are now free from dangerous pollution, although there are some on the Staten Island shore near the Narrows and the Kill von Kull, and a few in Gravesend Bay, which are nearer sewer outfalls than is proper.

(15) Analyses of oysters and clams show that shellfish which are grown or immersed for some hours in polluted water become polluted themselves.

(16) The increasing amount of pollution to which the waters of New York Bay are subject makes it seem only a question of time when oyster culture will be driven from this locality; but

with wise and careful protection, a large part of the present oyster grounds can be kept safe for years to come.

(17) The almost universal custom in this vicinity of "drinking," that is, bleaching and bloating, oysters in polluted streams of fresh water, places all shellfish in this market under suspicion of being contaminated.

(18) The pollution of the bay has had no visible effect upon the number of fish caught in the vicinity of New York, although petroleum and other industrial wastes have occasionally affected the flavor, and consequently the value, of shad.

(19) The transportation of passengers on ferry boats is one of the most important industries connected with the bay, the number of passengers transported in the New York district in 1903 having been 204 000 000, and the number which traveled directly across the center of the upper bay 8 811 000. This business would be seriously injured if the water became offensive to sight and smell.

(20) Unrestricted pollution of the bay would destroy the healthfulness and attractiveness of the parks and recreation piers which have been built by the city of New York on the water fronts for the benefit of the poor.

(21) Excursion steamers carried about 2 300 000 passengers to bathing beaches and other day summer resorts on or near the bay in 1903. The most important of these places are located a little beyond the Narrows in the lower bay and represent a total investment of several million dollars. The pollution of the bay, unless restricted, will eventually injure the healthfulness and business value of these resorts.

(22) The natural increase in population of New York and vicinity will, by 1930, increase the present amount of pollution about 65 per cent.

DISCUSSION.

Mr. Allen Hazen. — One of our New York dailies, speaking of Dr. Soper's admirable work in connection with the ventilation of the subway, referred to him as the best all-round germ detective in New York. I think he has fully justified that reputation to-night. Since he has investigated the oyster question I have had to forego the pleasure of eating them raw, almost entirely, and I am fond of oysters. It is only once in a great while, when he has been good enough to send up a bushel from his own private plantings, that I have been able to indulge that taste.

Mr. Weston has been talking to me about garbage disposal, and it was suggested that if we were more careful in our market-

ing, and if we had French cooks to save the scraps and to serve them to us in attractive form the day after, the quantity of garbage to be taken care of would be greatly reduced.

I do not know but we could go a little further. Supposing we were to regulate our food according to the dietaries of Mrs. Richards and limit ourselves to the number of calories that we really need, wouldn't the sewage disposal problem be largely solved? For I think that the troublesome matters are due largely to what we eat in excess of our actual needs. And that raises the question, What are the eating habits of the next generation going to be? Is it fair to make *per capita* computations based on the data of the present time and apply them to the twenty-first century without taking into account the dietaries of the people at that time, which we cannot hope to know?

Some weeks ago I took up these figures which Dr. Soper has used to-night, as they are given in the printed report of the New York Bay Pollution Commission, and went over them in a preliminary way, and made some pencil figures on the margins of the leaves of the pamphlet. The line of reasoning that I followed seems to offer some promise, and I should like to know what Dr. Soper thinks of it, and whether he has followed it to its conclusions.

The quantity of water that comes into New York Harbor through the Narrows and goes out again, if it is reduced to cubic feet per second, is a tremendous quantity. Altogether it represents a flow of over 3 cu. ft. per second per thousand of population, for 100 000 000 people. That is a pretty large population, more than the present population of the whole United States, but there can be no doubt that diluting the sewage from it with this amount of clean, cool sea water and with the strong tidal currents which exist would render it reasonably inoffensive.

But, of course, it is not true that all the water that comes in with every tide is new water. On the other hand, it is equally untrue to assume that the water that comes down the Hudson River and other tributaries of the bay, and which is represented by the line on Dr. Soper's chart for comparison with the sewage, is the only water available for diluting the sewage. If that were true, if the so-called piston method of computation were correct, if the water that comes back on the flood were the same water that went down on the ebb, then the water of New York Harbor would be fresh; there would not be a particle of salt water in it. The fact that there is salt water in the harbor, and lots of it,

is conclusive evidence that sea water comes in with every tide; and the fact that the water in New York Harbor is very salt is evidence that the volume of sea water coming in with each tide is enormous.

I took the figures from the report of Dr. Soper's commission. There are figures for the estimated volume of fresh waters coming in; for the volumes of tidal flow up and down; and for the percentage of sea water in the water at the different points, as computed from the chlorine of the water at the surface. From these it is easy to get an equation from which can be computed the proportion of the outgoing water that comes back again, and the proportion of new sea water which enters the harbor at each tide which has never been in the harbor before. And taking the figures from this same report and making the computation in this way, I found that about 79 per cent. of the water that once goes through the Narrows comes back again. The other 21 per cent. does not come back, but instead, 23 per cent. of the flood tide is made up of new sea water, water that has never been in the harbor before. And following the same computation at a point on the North River for which figures were given, the percentage was only one or two less, — almost the same thing.

Now these analyses relate to the water at the surface. Dr. Soper has told us about the underrun. It seems very clear to me that if that were taken adequately into account, the percentage of sea water that enters with every flood tide would be much larger than 23 per cent. But there are no data to figure that on. I think such data ought to be secured. I think perhaps the way to secure them would be to have a floating laboratory, such as is used in London, and which has been so largely instrumental in establishing the harbor conditions there. But such data do not exist at the present time. It is simply guessing to go beyond the figures in the report, and even those figures must be regarded as inadequate for such a computation. But if 23 per cent. of the water that comes in with every flood tide is new, fresh sea water, then that water would be sufficient to dilute to the extent I have mentioned the sewage from a population of 23 000 000 of people, — five times, in round numbers, the population now discharging sewage into the harbor, and Dr. Soper's analyses certainly bear out that proposition, for they indicate a water polluted to only a small fraction of the extent which would be necessary to make it offensive.

Of course, it is also true that when New York reaches such a population as 25 000 000, a great deal of it will be on Staten

Island and on Long Island, and so located that it will not discharge its sewage into the ocean through the upper harbor, and these computations do not take into account the conditions of the lower harbor, which are, no doubt, vastly more favorable for the dispersion of sewage. And so it looks as if it might be centuries rather than decades to the time when radical measures for purifying the sewage of New York City will be required.

There is another side. The degree of dilution of sewage in a body of water to render it satisfactory depends to a very large extent upon the uses to which the body of water is to be put. I have taken the ground strongly in some cases that the character of the body of water receiving sewage had to be taken into account. A standard suitable for one place is not suitable in another. In the case of a stream flowing through country where there are only a few scattered dwellings, the standard must be very different from that where the stream flows through a densely built-up territory and where a nuisance would be objectionable to thousands of people. And in New York Harbor millions would be affected.

I suppose there is no body of water in the world a bad condition of which would affect more directly and closely the comfort and happiness and even the health of a larger number of people; and it may be, when we come to that, that the degree of pollution allowable will be quite different from that which has been established by experience in other cases.

But at any rate, it looks as if any radical change in the method of disposal of New York sewage was a good long way in the future, and as if the habits of the people of future generations, and a lot of other things that we don't know much about, might be elements in the conditions that will finally control. And so I believe that what is wanted at this time is more investigation. I mean adequate and continued investigation of the condition of the water at different depths and at different places, and a study of the currents and of the conditions of sewage dilution. And that is what the situation calls for at the present time, rather than for any radical changes in the places at which sewage is discharged.

[NOTE: The computations upon which the above statements are based are as follows:

Let E = the volume of the ebb tide passing a given place;
Let R = the volume of river water in the ebb tide passing;
Let S = the average proportion of sea water in the ebb tide.

The total quantity of fresh water that goes out at one ebb will then be E(1–S).

Of this, R, the volume of river water, goes down not to come back. The rest of the fresh water going down, namely, E(1–S)–R, comes back with the flood tide.

The proportion of the total amount of fresh water which goes down not to come back is then

$$\frac{R}{E(1-S)}$$

It may be assumed that the proportion of sea water going down not to come back will be the same as the proportion of fresh water going down not to come back; for when once mixed it cannot be supposed that fresh and salt water will ever separate, and the proportion computed for fresh water may, therefore, be applied to the total volume of water going out with each tide.

Applying this to the Narrows, we have

E = 320 000 cu. ft. per sec. (computed from data on p. 35);
R = 23 883 cu. ft. per sec. (p. 38);
S = 65 per cent. (p. 67).

Percentage of the volume of each ebb which does not come back at the Narrows,

$$\frac{R}{E(1-S)} = 21 \text{ per cent.}$$

And for the Battery:

E = 161 000 cu. ft. per sec. (computed from data on p. 35);
R = say, 18 000 cu. ft. per sec.;
S = 45 per cent. (p. 67).

Percentage of the volume of each ebb tide which does not come back,

$$\frac{R}{E(1-S)} = 20 \text{ per cent.}$$

Of the gross amount of water flowing out of the Narrows with each ebb:

7 per cent. is river water on its last trip out;
28 per cent. is river water that will come back;
14 per cent. is sea water on its last trip out;
51 per cent. is sea water that will come back.

Allowing for the smaller volume of the flood tide as compared with the ebb, 23 per cent. of the whole volume of the flood tide must be new sea water which has never been above the Narrows before, equal to a flow of about 68 000 cu. ft. per sec. throughout the 24 hr.

It is well known that the average per cent. of sea water in the whole stream, taken from top to bottom, is far larger than in the surface water, which alone is represented in the data above indicated. If this difference could be taken into account, it is certain that the computed volume of new sea water entering the harbor with each tide would be much larger, — perhaps twice as large as the figure above computed.

There is another element of uncertainty in this computation. The amount of river water entering the harbor must vary enormously from month to month, and even from day to day. The figure given is understood to be a probable average figure. The actual flows when the samples from which the percentage of sea water was computed may have differed considerably from

Table Showing Extent of Shellfish Industry in Boston Harbor, 1905.

Location.	Estimated Quantity per Day When Taken.	Market.
Winthrop and Snake Island,	35 bushels*	Boston–Winthrop Private.
Chelsea Point to East Boston	Very few	Private.
Chelsea River	5 bushels	Boston.
Mystic River	15 bushels	Boston.
Old Harbor	3 bushels	South Boston.
Dorchester Bay	50 bushels†	Boston.
Moon Island	8 bushels‡	Nantasket.
Quincy Bay	5 bushels at Half Moon Island 5 bushels elsewhere	Nantasket. Private.
Weymouth Fore Fiver	5 bushels‡	Private or local.
Weymouth Back River	3 bushels	Private.
Hingham Harbor	8 bushels	Private. Nantasket.
Weir River	11 bushels	Private.
White Head to Allerton	5 bushels	Nantasket.
Apple Island	Few	Private.
Bird Island Flats	No clams; oysters planted yearly.	
Governor's Island	Few	Private.
Thompson's Island	5 bushels§	Boston.
Spectacle Island	5 bushels	Nantasket.
Long Island	Few	Private.
Rainsford Island	None.	
Peddocks Island	North side, none; south side, 4 bushels.	

* Dug mostly near Snake Island.

† Dug mostly along east side of river; very few dug from Squantum to Chapel Rock.

‡ Dug either side of roadway.

§ The larger quantity is dug on northwest shore.

the average, and, if so, this would make a difference in the result obtained. Data could be secured which would take this at least approximately into account, and a more accurate computation made, based upon such data.]

MR. X. H. GOODNOUGH.—*Results of the Examinations of Shellfish from Flats in Boston Harbor.* The range of tide in Boston Harbor is about 10 ft., and at low tide large areas of flats are exposed in nearly all parts of the harbor, many of which contain clams in considerable numbers. No definite information is available showing the number of clams collected for use as food from the clam flats in Boston Harbor, but in the course of the investigation estimates of the probable number taken from each of the different flats have been obtained from various sources, and the general average of these estimates is the best indication available as to the extent of the shellfish industry in Boston harbor.

Previously to 1905 a considerable number of samples of clams had been collected from the flats at several places in Boston Harbor and analyzed, the results showing, especially in the case of those collected from the flats in the Charles River, the presence of bacteria characteristic of sewage.

In 1905 the work of obtaining samples of clams from various localities in each of the flats was begun early in the season and completed in the latter part of October.

In the collection of the samples usually three clams were taken at each place and combined at the laboratory and analyzed as a single sample. The analysis consisted in determining whether *B. coli* were present either in the water in the shell of the clam or in the body of the clam itself. In many cases, owing to the presence of the organism known as sewage *Streptococcus*, the determination of the number of coli present was impracticable, and the presence of the sewage *Streptococcus* has been noted.

In all cases, samples of sea water have been collected at points adjacent to the places on the flats from which the samples of clams have been taken, and bacterial analyses of these samples of water have been made showing both the total number of bacteria present and the number of *B. coli* in the sample.

The following table contains a summary of the results of the examinations of samples of clams and sea water from the various localities, from which it appears that more than three quarters of the samples of clams collected in various parts of the harbor contained either the colon bacillus or sewage *Strepto-*

coccus and about 86 per cent. of the samples of sea water collected from waters adjacent to the flats contained the colon bacillus.

The results of the examination of samples of clams from 125 localities covering all portions of the harbor in which these shellfish could be found showed the presence of the colon bacillus or sewage *Streptococcus* either in the shell water or in the body of the clam in 96 of the samples, or about 77 per cent. of those examined. Out of the 144 samples of sea water collected at points opposite the clam flats, 124, or about 86 per cent., contained either the colon bacillus or sewage *Streptococcus*.

Summary of Results of the Examinations of Samples of Clams and Sea Water from Boston Harbor, 1905.

Location.	Number of Samples of Clams Examined.	Number Containing Coli in Body of Clam.	Number containing Sewage Streptococcus in Body of Clam.	Number Containing Coli in Shell Water.	Number Containing Sewage Streptococcus in Shell Water.	Number Containing Neither Coli nor Sewage Streptococcus in Body of Clam or in Shell Water.	Number of Samples of Sea Water Examined.	Number Containing Coli or Sewage Streptococcus.	Number Free from Coli or Sewage Streptococcus.
Old Harbor	5	2	1	5	0	0	7	7	0
Between Calf Pasture Pt. and Savin Hill	5	2	0	5	0	0	5	5	0
Savin Hill to Commercial Point	2	0	0	0	0	2	2	0	2
North side of Neponset River estuary	8	2	0	3	0	5	7	2	5
South side of Neponset River estuary	6	0	0	1	0	5	6	6	0
North side of Squantum	2	0	2	0	2	0	6	6	0
North side Moon Island causeway	2	0	2	1	0	0	3	3	0
South side Moon Island causeway	3	1	1	0	1	1	3	3	0
Squantum to Black's Creek	6	0	3	2	0	1	4	4	0
Black's Creek to Nut Island	3	3	0	1	0	0	2	2	0
Weymouth, Fore River	15	9	1	3	5	3	12	11	1
Weymouth, Back River	8	5	3	2	0	0	8	8	0
Weymouth, Back River to Crow Point	0	0	0	0	0	0	3	3	0
Hingham Bay	8	1	4	5	0	1	6	3	3
Nantasket Bay	7	5	1	4	1	1	10	10	0
Hull Bay	6	3	1	2	2	1	6	4	2
Mystic River above Chelsea Bridge	8	5	2	4	0	1	6	6	0
Chelsea River	3	3	0	3	0	0	6	6	0
East Boston to Chelsea Point	7	4	2	6	0	1	10	6	4
Chelsea Point to Point Shirley	7	2	1	1	2	3	7	7	0
Apple Island flats	1	1	0	1	0	0	3	1	2
Governor's Island Flats and Bird Island Flats	3	1	0	1	0	2	5	4	1
Thompson's Island	3	2	1	2	0	0	5	5	0
Spectacle Island	2	0	2	1	0	0	3	3	0
Long Island	3	0	3	3	0	0	6	6	0
Peddocks Island	2	0	0	0	0	2	3	3	0
Totals	125	51	30	56	13	29	144	124	20

No scallops or quahogs grow in this harbor and oysters do not grow there naturally. It is said, however, that a few oysters are planted in a shoal in the upper part of the harbor from which they are taken for consumption in the city, as needed.

At the same time that the samples of shellfish were being collected in various parts of Boston Harbor examinations of the water of the harbor were being made to determine its condition and the effect upon the waters of the harbor of the discharge into them of the sewage of the city and Metropolitan districts at various points. The results of these investigations show, in general, that the waters in all parts of the harbor are affected in a greater or less degree by pollution from the sewers and other wastes from the large population about it.

While in general the harbor is free from the appearance of sewage pollution, except in the immediate neighborhood of the sewer outlets, there can be no question of the serious danger to health involved in the use of oysters or other shellfish which have been planted at any point within the harbor or in the neighborhood of the islands at the mouth of the harbor, if these shellfish are used for food without thorough cooking.

A complete report of the results of the examination of the waters of the harbor will be published in the report of the Massachusetts State Board of Health for the year 1905.

Mr. H. W. Clark. — I will take but a very few minutes, Mr. President, and will speak only in regard to the shellfish side of this question. Dr. Soper has remarked that here in Boston we seem to like the Blue Point oysters. I'd like to say in reply to that that the Little Neck clams Mr. Goodnough mentioned as being gathered down near the New Bedford sewers go very largely to New York. That is, they did go to New York, but probably they won't keep on sending them after to-night. Mr. Hazen has spoken of the joys of eating raw oysters and also of the fact that he does not eat them any more unless Dr. Soper sends them to him. I presume, however, that he eats any old oyster that has been cooked from whatever source it comes. During the past five years we have been making a good many studies at the experiment station in regard to both raw and cooked oysters, and raw and cooked clams. We find, of course, that a considerable percentage of clams and oysters from sewage-polluted sources contains sewage bacteria, and that the clams and oysters from non-polluted sources are free, generally, from sewage bacteria. Through five years I have been running at Lawrence, with Mr. Gage's assistance, a scientific cooking

school that I think would make Mrs. Rorer green with envy. Some of you probably have heard of Mrs. Rorer. We have cooked clams and oysters in all the common ways and have bought such delectable dishes as oyster stews and clam chowders and fried clams in restaurants and hotels for examination at the laboratory, and never yet have bought an oyster stew for examination that did not contain many bacteria. We have found, during our work, that that very favorite, succulent New England dish known as steamed clams is not, when the shell of the clam opens,— the point at which the clams are considered fit to eat, — cooked or raised to a sufficient temperature to kill the bacteria present, and in order to kill coli, you have got to steam the clams until they are really unfit to eat.

We find in regard to oyster stew that the usual manner of making an oyster stew is to heat the milk to the boiling point, throw in the oysters and then serve as soon as possible. I think one of my men said he saw an oyster stew cooked and put before him in thirty seconds in one of the hotels here in the city. If the oysters in this stew were polluted and contained sewage bacteria, they still contained them when the stew was served; in fact, in order to make oyster stew safe to eat, you have got to cook the oysters for a considerable time in the milk. This makes the oysters somewhat tougher than some people like to have them. And the same with fried clams and fried oysters. While you can cook them so that the bacteria are killed, simply cooking them until the oysters and clams are considered in just the right condition to eat does not always kill the bacteria and does not destroy the coli present. In fact, it is pretty safe to say that when you eat cooked shellfish, you are not generally eating sterile shellfish; that is, danger is still present when you are eating cooked shellfish, although, of course, to a less degree than when eating raw shellfish.

Besides this, we have made experiments upon the keeping of oysters and clams under market conditions; that is, we have taken oysters and clams and polluted them by placing them in sewage-polluted water for a certain number of hours and then put them on ice, just as you see them piled up in oyster houses, etc., and examined a certain number each day, hoping when we started that the clams or the oysters would see fit to digest or destroy any sewage bacteria present and thus purify themselves. But we have found that the sewage bacteria stayed in the intestines of the clam or the oyster, or upon them, as long as we were able

to keep the shellfish alive upon ice, and that was some fourteen days, I think; so that you are not sure that keeping shellfish under market conditions kills or destroys the pollution; in fact, it generally does not. I do not think there is anything else I care to say about the question this evening.

[NOTE. Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by October 1, 1906, for publication in a subsequent number of the JOURNAL.]

Association of Engineering Societies.

Vol. XXXVI. JANUARY, 1906. No. 1.

PROCEEDINGS.

Engineers' Club of St. Louis.

St. Louis, December 6, 1905. — The 606th meeting of the Engineers' Club of St. Louis was called to order in the Club rooms, 3817 Olive Street, on Wednesday evening, December 6, 1905, at 8.15 P.M., President Flad presiding. Thirty-one members and four guests were present.

The minutes of the 605th meeting were read and approved.

The application of Mr. G. H. Elvis for membership in the Club was read and referred to the Executive Committee. Applications for membership from Mr. George B. Evans and Mr. Jacob D. von Maur were read and referred to the Executive Committee.

Nominations for officers of the Club for the ensuing year, in addition to those made by the Nominating Committee, were called for, but none were made.

The report of the Executive Committee, signed by the President, was read by the Secretary. It was ordered accepted and filed.

The report of the Secretary was read and ordered accepted and filed.

The report of the Librarian was read and ordered accepted and filed.

The report of the Treasurer was read. It was moved that it be referred to an auditing committee; motion amended by Mr. Layman to read that it be referred to an organized auditing company, for the purpose of securing not only an authoritative auditing, but suggestions for methods of keeping the accounts. Amended motion carried.

The report of the Entertainment Committee was read and ordered accepted and filed.

The report of the Board of Managers of the Journal was read and ordered accepted and filed.

Mr. Hans Toensfeldt, for the Committee on Regulation for Construction in Reinforced Concrete in St. Louis, reported progress and asked for further time. On motion the committee was ordered continued.

Mr. C. D. Purdon showed a series of photographs of a banana cooling plant installed by the Frisco Railroad at Springfield, Mo. The object of the plant is to cool the fruit from a temperature of about 78° fahr. to about 55° fahr., at the rate of about 0.75° per hour. Several of those present asked a number of questions about the operation of the plant.

It was moved by Mr. Brenneke that a sinking fund be established by the Club for the purpose of ultimately erecting a building for the Club headquarters. After some discussion, it was moved by Mr. Pfeifer that a committee of five be appointed to investigate the feasibility of such action and to report to the Club. The motion was amended to read that the new Executive Committee be charged with this duty. Amended motion carried.

Adjourned.

A. S. LANGSDORF, *Secretary pro tem.*

607TH MEETING, ST. LOUIS, DECEMBER 20, 1905. — The annual dinner of the Club was held at Hotel Jefferson, Twelfth and Locust streets, Wednesday evening, December 20, 1905. President Flad presided. Thirty-seven members and twenty-one guests were present.

After an excellent dinner, President Flad called the meeting to order and announced the election of the following officers for the year 1906:

President — W. A. Layman.

Vice-President — E. R. Fish.

Secretary — R. H. Fernald.

Treasurer — E. E. Wall.

Directors — C. A. Moreno and C. D. Purdon.

Members of the Board of Managers of the Association of Engineering Societies — A. P. Greensfelder, H. C. Toensfeldt.

President Flad then introduced the new President, Mr. W. A. Layman, as toastmaster for the evening. After brief introductory remarks the toastmaster called upon the retiring President for his address, after which the following list of toasts was responded to:

" The Engineer's Opinion of Himself," Robert Moore; " The Engineer in Print," William Marion Reedy; " The Engineer in Public Life," Andrew J. O'Reilly; " The Engineer in Trouble," Frederick W. Lehmann; " The Engineer and the Architect," William B. Ittner.

The toastmaster then called upon Prof. C. M. Woodward to respond to " The Infant Engineer," after which the meeting adjourned promptly at midnight.

R. H. FERNALD, *Secretary.*

ST. LOUIS, JANUARY 3, 1906. — The Engineers' Club of St. Louis held its 608th meeting at the Club rooms, 3817 Olive Street, Wednesday evening, January 3, 1906. President Layman presided. There were present twenty-three members and seven guests.

The minutes of the 606th and 607th meetings were read and approved. The minutes of the 397th, 398th and 399th meetings of the Executive Committee were read.

Applications for membership from the following gentlemen were presented and referred to the Executive Committee: William Alfred Baehr, John Robert Cullinane, Frank W. Combs, Edward G. Cowdery, C. Wellington Koiner, Samuel Carson McCormack, Arthur S. Partridge, Henry F. Rosenow, Arthur Henry Timmerman, Guy Anderson Watkins.

The following were elected to membership in the Club: George Harvey Elvis, George B. Evans, F. H. Pearson, Jacob D. von Maur.

The resolution of the Executive Committee relating to a committee of three on expansion of membership (see minutes of 399th meeting of Executive Committee) was presented to the Club for action. Upon motion of the Secretary the Club approved the resolution and authorized the President to appoint the committee. The President appointed Mr. A. H. Zeller, chairman, Mr. Richard McCulloch and Gerard Swope.

Upon motion of Mr. Greensfelder a vote of thanks was extended to Messrs. Baehr, Von Maur and Evans, of the Laclede Gas Light Company, for the very cordial reception extended to the members of the Engineers' Club upon the occasion of the recent visit of the Club to the plant of the above-named company.

An excellent paper was presented by Mr. R. E. Einstein, upon "Frogs and Switches." The paper was discussed by Messrs. Pfeifer, Greensfelder, Phillips and Flad.

The President then introduced Mr. Day and Mr. Lauer, of Philadelphia, experts on factory conditions. Mr. Day gave a very interesting outline of the work in which they are engaged, explaining its origin, necessity and rapid development.

Adjourned.

R. H. FERNALD, *Secretary.*

Civil Engineers' Club of Cleveland.

REGULAR MEETING, DECEMBER 12, 1905, at the Club rooms, called to order by the President at 8.15 P.M. Present, thirty members.

Minutes of preceding meeting read and approved.

The tellers, Mr. Lane and Mr. Hanlon, reported the election to active membership of Louis A. Corlett, Philo A. Orton, George H. Rose and Adolphus E. Sprackling.

Owing to the illness of General Smith, the paper scheduled for this meeting could not be given, and in lieu of it the President called for a discussion of some current topic.

Mr. Tinker presented the subject of the present law governing the clearance of overhead railroad bridges, citing the case of the new bridge now being constructed over the New York, Chicago & St. Louis Railroad, at Detroit Street, in this city, in which the clearance is only a little over 16 ft., the small head room in this case not only endangering the lives of employees, but causing the cutting down in height of some of the rolling stock.

This subject was discussed at length by Messrs. Nelles, Green, Lane, Hanlon and others. On motion of Mr. Lane, a committee of three (Messrs. Hanlon, Hoffman and Fox) was appointed by the President to investigate the present law on the subject and report to the Club what changes in it might be desirable.

President Green presented the subject of the making of concrete at a temperature of 25° fahr., which was discussed by Messrs. Herman, Nelles, Tinker, Lane and others.

Adjourned.

JOE C. BEARDSLEY, *Secretary.*

Regular Meeting, January 9, 1906, at the Club rooms, called to order by the President at 8.15 p.m. Present, forty-two members and visitors.

Minutes of preceding meeting read and approved.

The President announced the appointment of Mr. Rice to be chairman of the Committee on Water Pollution in place of Colonel Kingman, at the request of the latter.

The President also announced the appointment of Messrs. Bidwell, G. A. Hyde and Hinchman as a Committee on Resolutions on the death of Mr. William Chisholm, on December 6 last. Mr. Bidwell presented the appended resolutions from this committee. On motion of Mr. Lane, they were unanimously adopted.

Nominations for the Nominating Committee being called for, Mr. Henderer placed in nomination the last seven past presidents, who are eligible, viz.: Dr. Howe, Messrs. Ritchie and Osborn, General Smith and Messrs. Hopkinson, Benjamin and Wellman. On motion of Mr. Lane, nominations were closed and the Secretary instructed to cast the ballot of the Club for the nominees above named.

The paper of the evening, "The Use of Suction Gas Producers for Power Purposes," was then given by Mr. N. T. Harrington, of the Olds Gasoline Engine Works, of Lansing, Mich. A general discussion followed the reading of this very interesting paper, many members taking part.

Adjourned.

Joe C. Beardsley, *Secretary.*

Boston Society of Civil Engineers.

Boston, Mass., December 20, 1905. — A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, Boston, at 8 o'clock p.m. President John W. Ellis in the chair; one hundred and thirty-four members and visitors present.

The record of the last meeting was read and approved.

Messrs. David A. Ambrose and William V. Moses were elected members of the Society.

Mr. George S. Rice gave a very interesting talk on the "Construction of the New York Subway." The talk was illustrated by a large number of lantern slides.

Adjourned.

S. E. Tinkham, *Secretary.*

Boston, January 24, 1906. — A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, Boston, at 7.45 o'clock p.m. President John W. Ellis in the chair; ninety-six members and visitors present.

The record of the last meeting was read and approved.

Messrs. Carl P. Abbott, Paul A. Babcock, John Campbell, Edwin W. Ellis and Frank C. Kimball were elected members of the Society.

On motion of Mr. C. W. Sherman, the President was requested to appoint a committee of three to retire and report to the meeting the names of five members to serve as a committee to nominate officers for the ensuing year. The President appointed as that committee, Messrs.

C. W. Sherman, A. H. French and G. A. King. Later in the meeting this committee reported the following names as members of the Nominating Committee and they were elected unanimously: Messrs. J. Parker Snow, I. T. Farnham, F. A. Barbour, A. T. Safford and C. M. Saville.

On motion of Mr. Adams, the President was requested to appoint the usual committee to make arrangements for the annual dinner of the Society. The President named as that committee Mr. Henry Manley.

On motion of the Chairman of the Excursion Committee, the thanks of the Society were voted to the following officers of the Revere Rubber Works, for courtesies extended to members of the Society this afternoon on the occasion of the visit to the works of the company: C. P. Converse, president; E. S. Williams, general manager; Frank Veazie, superintendent; and J. S. Patterson, assistant superintendent.

The literary exercises of the evening consisted of two very interesting talks, fully illustrated by lantern slides. The first by Prof. L. P. Kinnicutt, entitled, "An Informal Talk about a Visit in 1905 to the Percolating Sewage Filters at Birmingham and the Contact Beds at Manchester, England," and the second by Prof. William T. Sedgwick, of the Massachusetts Institute of Technology, on "Observations of a Sanitarian in Sicily and Other Parts of Southern Europe."

After passing a vote of thanks to Professor Sedgwick, who was not a member of the Society, the meeting adjourned.

S. E. Tinkham, *Secretary*.

Civil Engineers' Society of St. Paul.

St. Paul, Minn., January 8, 1906. — The twenty-third annual meeting of the Civil Engineers' Society of St Paul was held in Parlor 117 at the Merchants' Hotel at 6.30 p.m.

Seventeen members and five visitors in attendance.

President Starkey in the chair.

The minutes of previous meeting were read and approved.

The reports of the Secretary, Treasurer and Librarian were read and accepted.

Mr. Oscar Claussen was elected president and Mr. James D. DuShane vice-president. The remaining officers were reelected without the formality of the individual ballot.

Upon taking the chair, after a few appropriate remarks, President Claussen appointed Mr. Starkey and Mr. Munster to audit the Treasurer's accounts, and the Secretary was instructed to advise Mr. Charles Warren Hunt, secretary, that the members of the American Society of Civil Engineers would be cordially welcomed to our library at any time, and to our meetings, which are regularly held on the second Monday of each month, June to September inclusive excepted.

At 7.20 the meeting adjourned to the dining room. After dinner, the subjects of river improvement, good roads, etc., were discussed, the following gentlemen offering apt and interesting remarks: H. H. Harrison, Captain Powell, Major DuShane, C. A. Forbes, Professor Hoag, Oliver Crosby, E. P. Burch and F. W. Cappelen.

Adjourned at 9.30 p.m.

C. L. Annan, *Secretary*.

Technical Society of the Pacific Coast.

San Francisco, December 1, 1905. — A meeting was held for the purpose of electing a nominating committee to prepare a ticket of officers for the ensuing year.

President Dickie called the meeting to order, and the following were elected by the members present: Stetson G. Hindes, chairman; W. J. Cuthbertson, Edward F. Haas, S. C. Irving, Adolf Lietz.

The Secretary was instructed to inform these members of their election, and to request the chairman to call a meeting for the purpose set forth.

Meeting thereupon adjourned.

Otto von Geldern, *Secretary.*

Autumnal Meeting, San Francisco, December 14, 1905. — Called to order on Thursday evening, December 14, 1905, at 8 o'clock, by President Dickie, who welcomed the members and guests in the name of the Society.

The paper of the evening was written by Mr. Edward T. Hewitt, who was not present (it was read by his brother, Mr. William A. Hewitt), and treated of the " Modern Polytechnic High School," describing in detail the construction and arrangement of the Los Angeles Polytechnic School, with which Mr. Hewitt is directly connected. Plans and sections of the buildings were laid before the members, who discussed the subject in its various phases at some length; after which the meeting adjourned.

Otto von Geldern, *Secretary.*

Autumnal Meeting, Friday, December 15, 1905. Afternoon Session. — Called to order at 2 o'clock by President Dickie. Mr. Frank P. Medina read a paper entitled, " Property in Invention," which was discussed, after which the meeting adjourned until 8 o'clock p.m.

Evening Session. — Called to order at 8 o'clock, by President Dickie.

The minutes of the two previous meetings were read and approved.

The first paper of the evening was read by Mr. W. J. Cuthbertson, in which he suggested a " Solution of Metropolitan Transit," by the provision of central structures for the street car and vehicle traffic, and subways for all utilitarian conduits. The suggestion was illustrated by sketches showing the ideas involved in this method of proposed municipal improvement.

A discussion of this subject took up most of the evening, after which the Secretary read a paper, written by Mr. James C. Bennett, entitled " A Method of Filing Notes, Clippings and Sketches," which was also discussed.

The meeting thereupon adjourned.

Otto von Geldern, *Secretary.*

The Banquet of the Technical Society of the Pacific Coast, December 16, 1905. — In this event, held at the Merchants Club in San Francisco, sixty members and guests participated. The President

acted as toastmaster, and a most pleasant evening was spent in thus concluding the Autumnal Meeting of the Society.

In the address of the President, Mr. Dickie referred to the long struggle of the Society, and its constant desire to accomplish something to benefit the engineer. He related his own experiences in his career on the Pacific coast, from the time of his arrival in San Francisco,referring to his connection with many engineering works of the state.

The members and friends parted at midnight by singing "Auld Lang Syne."

Otto von Geldern, *Secretary.*

San Francisco, January 5, 1906. — Regular meeting called to order at 8 o'clock p.m. by President Dickie.

The report of the Nominating Committee was read as follows:

January 5, 1906.

To Members of Technical Society,
San Francisco, Cal.

Gentlemen, — Your Nominating Committee takes pleasure in presenting the following names for nomination of officers for the coming year:

For President — Mr. George W. Dickie.
For Vice-President — Mr. Franklin Riffle.
For Secretary — Mr. Otto von Geldern.
For Treasurer — Mr. E. T. Schild.
For Directors — Mr. Carl Uhlig, Mr. Hermann Barth, Mr. Marsden Manson, Mr. H. D. Connick, Prof. Herman Kower.

Respectfully submitted,

S. G. Hindes,
W. J. Cuthbertson,
Edw. F. Haas,
S. C. Irving,
Adolf Lietz,
Nominating Committee.

Upon motion the report was ordered received, the committee discharged, and the Secretary instructed to prepare and circulate ballots to be opened on the evening of the annual meeting, January 19, 1906.

The chair appointed as tellers for the ballot Messrs. W. J. Cuthbertson and Harry Larkin.

A note was read from Mr. M. H. Strouse, assistant to the secretary of the Pacific Northwest Society of Engineers, stating that three of the papers read at the Engineering Congress held at Portland in 1905 had been recovered, viz.: "Problems that Confront Engineering and Kindred Industries on the Pacific Coast," by George W. Dickie; "Subterranean Water Supply," by John Richards; and the "Principles Governing the Valuation for Rate Fixing Purposes of Water Works under Private Ownership," by Arthur L. Adams. The expense incurred amounted to twenty dollars, and the Society is asked to contribute a part of this amount in order to reimburse the Pacific Northwest Society for its outlay to recover what is considered the property of the Technical Society.

The Secretary was instructed to communicate with the Pacific Northwest Society and ascertain the pro rata of the Technical Society in the expenditure connected with the recovery of these papers, and that this amount be thereupon drawn on the Treasurer and sent to the secretary with the expressed appreciation of the Technical Society.

Meeting thereupon adjourned.

OTTO VON GELDERN, *Secretary.*

ANNUAL MEETING, SAN FRANCISCO, JANUARY 19, 1906. — The meeting was called to order at 8.30 P.M. by the President. The ballots for the annual election of officers were opened by the tellers and the following result of the balloting was announced:

For President — George W. Dickie, 55.
For Vice-President — Franklin Riffle, 55.
For Secretary — Otto von Geldern, 54.
For Treasurer — E. T. Schild, 55.
For Directors — Hermann Barth, 55; H. D. Connick, 54; Hermann Kower, 55; Marsden Manson, 54; Carl Uhlig, 55.

These officers were thereupon declared duly elected to serve the Society for the year 1906. The annual reports of the Secretary and Treasurer were read, which were ordered approved and spread in full upon the minutes. The meeting thereupon adjourned.

E. T. SCHILD, *Acting Secretary.*
(In the absence of Otto von Geldern, *Secretary.*)

ANNUAL REPORT OF THE SECRETARY FOR THE YEAR 1905.

I have the honor to submit to the Society, through its Board of Directors, the following report, containing also that of the Treasurer, showing the condition of the Society on January 19, 1906, the date of the regular annual meeting.

The present total membership is 166, as follows:

Honorary member	1
Life members	3
Members	144
Associates	18
Total	166

Of these the following classification may be made:

Resident members	100
Non-resident members	48
Resident associates	17
Non-resident associates	1
Total	166

Geographically distributed, there are in

San Francisco and vicinity	115
Northern California	22
Southern California	5

Arizona	1
Colorado	1
District of Columbia	2
Hawaii	3
Kansas	1
Massachusetts	1
Nevada	2
New York	2
Oregon	4
Washington	1
Wyoming	2

FOREIGN.

British Columbia	1
Central America	1
South Africa	2
Total	166

Professionally divided there are,

Architects	11
Builders	7
Chemists	2
Civil engineers	77
Draftsmen	2
Electrical engineers	5
Instrument makers	2
Manufacturers	4
Mechanical engineers	29
Merchants	2
Military engineers	2
Mining engineers	10
Naval architect	1
University professors	5
Surveyors	7
Total	166

ADMISSIONS IN 1905.

By Election.

Members	7
Associate	1

As Sojourner.

Member	1
Total	9

Membership of the Society at the end of the year 1904:

Members and associates	173
Admissions in 1905	9
Total on membership list during the past year	182

LOSS DURING THE YEAR.

By death	2
By resignation	9
By suspension	3
Cessation of membership	2
Total	16

Carried on the membership list during the past year, 1905	182
Loss in 1905	16
Present membership	166
Membership at beginning of year	173
Loss during the year 1905	7

DEATHS DURING THE YEAR.

1. Burr Bassell, member, died at Los Angeles, Cal., February 25, 1905.
2. Col. George H. Wallis died at San Francisco, March 19, 1905.

During the year the Society added to its membership the following:

BY ELECTION.

Members.

Arthur L. Adams, civil engineer, San Francisco, Cal.
Charles E. Beugler, civil engineer, Oakland, Cal.
Russell Chase, civil engineer, Portland, Ore.
S. C. Freeland, civil engineer, Portland, Ore.
Julius M. Howells, civil engineer, San Francisco, Cal.
Willis Polk, architect, San Francisco, Cal.
Clarence R. Weymouth, mechanical engineer, San Francisco, Cal.

Associate Member.

William H. Alderson, civil engineer, San Francisco, Cal.

BY ADMISSION AS SOJOURNING MEMBER.

Capt. W. W. Harts, Corps of Engineers, United States Army.
Total, 9.

RESIGNATIONS DURING THE YEAR 1905.

Members.

L. J. LeConte, civil engineer, Oakland, Cal.
H. D. Gates, civil engineer, San Francisco, Cal.
Major C. E. Gillette, corps of engineers, United States Army.
R. S. Moore, mechanical engineer, San Francisco, Cal.
James M. Owen, draftsman, San Francisco, Cal.
William C. Pidge, surveyor, San Francisco, Cal.
G. W. Wepfer, mining engineer, non-resident.
J. H. G. Wolf, civil engineer, California.

Associate Member.

George Stone, cement manufacturer, San Francisco, Cal.

Total, 9.

SUSPENSIONS DURING THE YEAR 1905.

S. Giletti, concrete builder, New York.
George W. Nicholls, electrical engineer, non-resident.
E. F. Rossow, draftsman, Mare Island.

Mr. John Richards, past president, was made an honorary member during the year, for his eminent services rendered the Society in the past, and as a token of appreciation for them on the part of the members of the Technical Society.

Two meetings were held during the year for the purpose of reading and discussing papers on technical subjects:

THE SPRING MEETING,

in Portland, Ore., during the Lewis and Clark Exposition, on June 29 and 30, and July 1, 2 and 3, in conjunction with other organizations which participated in holding an Engineering Congress:

Pacific Northwest Society of Engineers, Technical Society of the Pacific Coast, Pacific Coast Electrical Transmission Association, Officers of the Corps of Engineers, United States Army; Engineers of the United States Reclamation Service, Montana Society of Engineers, Washington State Chapter of American Institute of Electrical Engineers.

The following papers were submitted for reading and discussion by members of the Technical Society during this joint congress:

1. "Pacific Coast Industrial Engineering Problems," by George W. Dickie.

2. "The Principles Governing the Valuation of Water Works under Private Ownership," by Arthur L. Adams.

3. "Subterranean Water as Found in the Valleys of California," by John Richards.

4. "Timber Tests — Methods and Results," by Loren E. Hunt.

5. "Reinforced Concrete Construction," by L. A. Hicks.

6. "Control of Hydraulic Mining Débris in California Rivers by the Federal Government," by Capt. W. W. Harts, Corps of Engineers, United States Army.

7. "The United States Reclamation Service," by D. C. Henny, consulting engineer.

THE AUTUMNAL MEETING

was held in San Francisco, December 14, 15 and 16, where the following papers were read and discussed:

1. "Annual Address," by the President, George W. Dickie.

2. "Description of the Polytechnic High School of Los Angeles," by Edward T. Hewitt.

3. "Property in Invention," by Frank P. Medina.

4. "A Suggested Solution of Metropolitan Transit," by W. J. Cuthbertson.

5. "A Method of Filing Notes, Clippings and Sketches," by James C. Bennett.

TREASURER'S REPORT FOR THE YEAR 1905.

Cash in bank January 7, 1905		$474.52	
Cash on hand January 7, 1905		44.80	
			$519.32
Received during the year to January 6, 1906			1 086.40
			$1 605.72
Expended during the year to January 6, 1906			$1 115.21
Cash in bank January 6, 1906		$481.51	
Cash on hand January 6, 1906		9.00	490.51
			$1 605.72

The receipts are as follows:

Cash in bank January 7, 1905		$474.52	
Cash on hand January 7, 1905		44.80	
			$519.32
Dues collected			878.00
Eight admission fees			40.00
Dues, account of Mechanics Institute			10.50
Cash for reprints			29.20
Sundries, diplomas, etc			11.70
Banquet tickets			117.00
			$1 605.72

The expenditures are as follows:

Sundry expenses, stamps, envelopes, mailing, etc.		$113.20	
Printing, stenographing, typewriting, etc		148.00	
Salary of secretary		180.00	
Collecting		67.74	
Four assessments, Fred. Brooks, secretary		411.57	
Dues, Mechanics Institute		20.50	
Reprints, Fred. Brooks, secretary		27.70	
Books and subscriptions		4.00	
Banquet	$127.50		
Steward at banquet	10.00		
Services at fall meeting	5.00	142.50	
			$1 115.21
Cash in bank January 6, 1906		$481.51	
Cash on hand January 6, 1906		9.00	490.51
			$1 605.72

Engineers' Society of Western New York.

ANNUAL MEETING, BUFFALO, N. Y., DECEMBER 5, 1905. — The meeting was held in the rooms of the Society in Ellicott Square at 4 P.M., and in the evening at the Hotel Touraine.

There were present Messrs. Alverson, Babcock, Bassett, Brackenridge, Eighmy, Fairchild, Fell, Haven, Kielland, Knapp, Norton, Ricker and Throop.

The minutes of the last meeting were read and approved.

Messrs. Bassett and Kielland were appointed tellers to count the ballots for officers for the ensuing year.

President Norton announced the following-named persons as having been duly elected:

President — Louis H. Knapp.
Vice-President — Soren M. Kielland.
Director — Frank N. Speyer.
Secretary — Thomas J. Rogers.
Treasurer — Dennison Fairchild.
Librarian — William A. Haven.

The Treasurer presented the following report for the year ending December 5, 1905:

December 5, 1905.

To the President and Members of the Engineers' Society of Western New York:

Gentlemen, — Herewith I submit for your approval my annual report for the year ending December 12, 1905, as follows:

RECEIPTS.

Balance in treasury, December 1, 1904	$314.23
From Secretary and others	505.75
From banks, interest	11.59
Total	$831.57

DISBURSEMENTS.

Rent, October 1, 1904, to September 1, 1905, 11 mo.	$261.00	
Association Engineering Society, assessments	115.00	
Postage, printing and stationery	60.94	
Binding magazines, etc.	23.25	
Binding board	1.60	
Maps and postage on same	4.51	
Subscriptions for magazines, etc.	20.70	
Typewriting	9.47	
Advertisements	24.00	
Funds in Erie County Bank, December 12, 1905	295.68	
Funds in Fidelity Bank, December 12, 1905	15.42	
Total		$831.57

BALANCE ON HAND.

General fund (Fidelity Bank)	$15.42	
Library fund (Erie County Bank)	33.44	
Permanent fund (Erie County Bank)	262.24	
Total		$311.10

Very respectfully,

F. N. Speyer, *Treasurer.*

The following report was received from the Secretary:

BUFFALO, N. Y., December 5, 1905.

ANNUAL REPORT OF THE SECRETARY FOR THE YEAR, DECEMBER 1, 1904, TO DECEMBER 1, 1905.

TO THE PRESIDENT AND MEMBERS OF THE ENGINEERS' SOCIETY OF WESTERN NEW YORK:

Gentlemen, — I herewith beg to submit the following annual report for the year ending December 1, 1905:

MEMBERSHIP.

Honorary member	1
Members	46
Associates	9
Juniors	–
Total	56

During the year the following changes in membership have occurred:

Deaths	2
Resigned	8
Indefinitely suspended account of arrears of dues	17
	27

RECEIPTS AND DISBURSEMENTS.

Annual dues	$417.50
JOURNAL advertisements	80.00
Annual banquet " bal "	.75
	$498.25
Deposited with Secretary	$498.25
There are in arrears of dues at present, 15 members on the active list, owing	$177.50

MEETINGS.

The Society held three meetings, with an average attendance of eleven, against seven meetings and an average attendance of nine the previous year.

Six meetings of the Executive Board were held, with an average attendance of five, against twelve meetings with an average attendance of five for the previous year.

At the regular meetings the following subjects were discussed:

January 3, 1905. " What Should be the Policy of the City Toward the Development of Its Outer Harbor?"

February 7, 1905. " The Union Passenger Station."

October 3, 1905. " The Present Condition of the City Water Works.

An amendment to the Constitution, Act VI, was announced as having been carried at the February meeting, and amendments to the By-Laws, Act VI, Sect. 12, and Act V, Sects. 1 and 2, at the January meeting.

Very respectfully,

H. B. ALVERSON, *Secretary.*

The reports of the Treasurer and Secretary were received and ordered printed, and the President was requested to appoint a committee to audit their accounts.

President Norton made a short address on the state of the Society and took occasion to thank the members for their interest in the affairs of the Society. Informal remarks were made by Messrs. Bassett, Brackenridge, Babcock, Kielland and Ricker.

A vote of thanks to the retiring officer was unanimously adopted.

H. B. Alverson, *Secretary.*

Association of Engineering Societies.

Vol. XXXVI. FEBRUARY, 1906. No. 2.

PROCEEDINGS.

Engineers' Club of St. Louis.

St. Louis, January 17, 1906. — The Engineers' Club of St. Louis held its 609th meeting on Wednesday evening, January 17, 1906, at the Club rooms, 3817 Olive Street, President Layman in the chair. Present. also, thirty-four members and eight guests.

The minutes of the 608th meeting were read and approved.

In the absence of the Secretary, the President presented a partial report of the 400th meeting of the Executive Committee.

New applications for membership from the following gentlemen were read: Herbert William Wolff, Henry Clay Henley, Grant Beebe, John C. Van Doorn, Walter Lee Flower, Wesley W. Horner.

The applications of the three following gentlemen, which were read at the last meeting, having been referred to the sponsers for further information, were again presented:

Frank W. Combs, Edward G. Cowdery, Samuel Carson McCormack.

The applications of the following gentlemen having been duly approved, were voted upon and the men named elected: W. A. Baehr, J. R. Cullinane, C. W. Koiner, A. S. Partridge, H. F. Rosenow, A. H. Timmerman, G. A. Watkins.

The President presented for action by the Club a recommendation of the Executive Committee that a vest-pocket list of the Club membership be printed, the cost to be borne by a sufficient amount of advertising at twenty dollars per page.

After some discussion it was moved (Van Ornum) and seconded that the matter be referred back to the Executive Committee for further consideration, particularly with regard to the elimination of advertising, and also with regard to the form of the publication.

A substitute motion, duly seconded and accepted by Van Ornum, was made by R. S. Colnon, that the Secretary be authorized to publish a roster of Club membership, without advertising, at a cost not to exceed $250, and in a form to be fixed by the Executive Committee.

The motion was amended to read that the publication be in pamphlet form, of the size of the Journal.

The last amendment was then amended to read that the pamphlet contain, in addition to the membership list, the Constitution and By-

Laws, and such other matter as the Executive Committee may direct. Amendment carried.

Preceding amendment, as amended, carried.

Original motion, as amended, carried.

The President announced that Mr. Swope was unable to accept the appointment to the Membership Committee and that Mr. Wm. H. Bryan had been appointed to fill the vacancy.

The discussion of the evening was then opened by Mr. S. Bent Russell, who read extracts from a paper by Mr. A. J. Himes, entitled, "The Position of the Constructing Engineer and His Duties in Relation to Inspection and the Enforcement of Contracts," and added his views of the subject from the standpoint of the engineer. Mr. R. S. Colnon replied from the standpoint of the contractor.

The discussion was also participated in by Messrs. Robert Moore, Wm. H. Bryan, E. R. Fish, S. B. Russell, R. S. Colnon and Mr. J. N. Ostrom of Pittsburg.

Adjourned.

A. S. Langsdorf, *Secretary pro tem.*

St. Louis, February 7, 1906. — The 610th meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, Wednesday evening, February 7, 1906, President Layman presiding. Forty members and five visitors were present.

The minutes of the 609th meeting were read and approved, and the minutes of the 401st meeting of the Executive Committee were read.

Applications for membership were read from Henry Elliot and Perse Abram Morse.

The following, having been approved by the Executive Committee, were elected members of the Club: Grant Beebe, F. W. Combs, E. G. Cowdery, W. L. Flower, H. C. Henley, W. W. Horner, S. C. McCormack, J. C. Van Doorn, H. W. Wolff.

The President announced the following Entertainment Committee for 1906: H. J. Pfeifer (chairman), A. S. Langsdorf, J. V. Hanna, W. H. Baehr, W. H. Henby.

The report of the Executive Committee, relating to the appointment of a committee to furnish information to the Club regarding the investigations which are being made by the United States Geological Survey Testing Plant located in St. Louis, was presented to the Club. After remarks by Messrs. Flad, Bryan and Holman, Mr. Flad moved that such a committee be appointed. The motion was carried.

The President named the following men to serve on the committee: Edward Flad (chairman), M. L. Holman, Robert Moore, W. H. Bryan.

An invitation was read from the Academy of Science, inviting the Engineers' Club to be represented at the dinner commemorative of the fiftieth anniversary of the foundation of the academy. The Secretary was instructed to ascertain more definitely regarding the nature of representation desired by the Academy of Science.

The report of the examiner appointed to audit the Treasurer's accounts for 1905 was read to the Club. The report showed the Club to be in excellent financial condition and the Secretary's and Treasurer's records correct.

Mr. Robert Moore moved that the Library Fund be made $250 for the year 1906, the total ($250) to include the amount at present in the Library Fund.

The paper of the evening, upon "Railroad Construction in the Southwest; or, Meeting with Extremes," by Mr. H. Rowher, was fully illustrated by lantern slides. The paper would have provoked considerable discussion, but owing to the lateness of the hour, the discussion was postponed until the following meeting.

Adjourned.

R. H. FERNALD, *Secretary.*

Civil Engineers' Club of Cleveland.

RESOLUTIONS on the death of Mr. William Chisholm (adopted January 9, 1906):

Whereas, It has pleased the Divine Power, whose ways are beyond mortal ken and before whose chastening dispensation we humbly bow, to remove from this life our esteemed associate, William Chisholm; therefore, be it

Resolved, That in the death of William Chisholm the Civil Engineers' Club of Cleveland loses a faithful member, an earnest supporter, an encouraging influence and a gracious personality.

Resolved, That we, the members of the organization, mourn the loss of one whose fellowship was uplifting, whose friendship was unwavering, whose gentle and unobtrusive nature endeared him to all who knew him, and whose vacant chair in our broken circle will long be a tender reminder of the bereavement we sustain through the loss of his counsel and his companionship. And be it further

Resolved, That these resolutions, suitably engrossed, be sent to the family of our late associate, and that they be furnished to the local newspapers for publication.

(Signed) JASON A. BIDWELL,
GUSTAVUS A. HYDE,
C. R. HINCHMAN,
Committee.

REGULAR MEETING, FEBRUARY 13, 1906, at the Club rooms, called to order by the President at 8.15 P.M. Present, fifty members and twelve visitors, the latter including Messrs. Lehman and Schmitt, architects for the new Court House, and Mr. John Eisenman, who were especially invited to be present at this meeting.

Minutes of preceding meeting read and approved.

Applications from the following for active membership, approved by the Executive Board, were read: Charles John Conlin, George Ellis Daniels, M.E., Philip A. Geier, John Christian Ulmer, Clarence H. Judson (transfer from Toledo Club) and John Christian Streng (transfer from Detroit Society).

The following amendment to the Constitution was reported from the Executive Board with the unanimous approval of the Board, and was referred to letter ballot at the next regular meeting of the Club: Article II, Section 6, to read as follows: "Honorary members shall be gentlemen of acknowledged preëminence in engineering, architecture or applied science. They shall be subject to neither fees nor assessments. The number of honorary members shall be limited to *ten*." The word "ten," at the end of the section is substituted for "six" in the original.

Mr. Hanlon, chairman of the Grade Crossing Committee, submitted the appended majority report from his committee, signed by himself and Mr. Cox, together with a minority report, also appended, signed by Mr. Hoffman, the third member of the committee.

After an extended discussion, taken part in by Colonel Kingman and Messrs. Hanlon, Hoffman, Tinker and Lane, a motion by Mr. Hoffman was carried to accept the majority report and refer back to the committee the question of minimum clearance considered desirable, for further investigation and report at the next regular meeting.

The Nominating Committee submitted the following list of nominations for officers for the ensuing year: For President, Dr. Dayton C. Miller; Vice-President, Charles H. Wright; Secretary, Joseph C. Beardsley; Treasurer, Walter M. Allen; Librarian, Harry S. Nelson; First Director, Robert O. Rote; Second Director, Henry M. Lane; and Director to fill out the unexpired term of Mr. Wright, Henry M. Lucas.

(Signed) CHARLES S. HOWE, *Chairman.*

The list was referred to letter ballot at the annual meeting, without discussion.

Mr. Hoffman presented for endorsement by the Club, H. B. No. 122, Mr. Lersch, now pending in the General Assembly, " to investigate the construction, the methods of operation and the efficiency of all water purification works and sewage purification works in use by cities, villages and public institutions in the state of Ohio," and providing an appropriation of $7 500 per annum therefor, for two years. The Secretary reported that the Committee on Water Pollution had examined the proposed bill and approved its provisions. On motion of Mr. Lane, seconded by Colonel Kingman, the Secretary was instructed to communicate with the legislative delegation from this county, urging the adoption by the Assembly, of the proposed legislation.

Gen. J. A. Smith then presented the paper of the evening, a discussion of " Some Phases of Foundations for Buildings in Cleveland."

Following the reading of the paper, at the suggestion of Mr. Boalt, Messrs. Lehman and Schmitt, architects for the new Court House, were invited to take part in the discussion. Mr. Lehman responded by presenting an exhaustive paper on the subject of the Court House foundation which appears in the discussion of General Smith's paper.

Mr. Hanlon then moved to adjourn for two weeks and to continue the discussion at the special meeting to be held at that time. Carried.

Lunch was served after adjournment.

JOE C. BEARDSLEY, *Secretary.*

CLEVELAND, OHIO, January 22, 1906.

TO THE PRESIDENT AND MEMBERS OF THE CLEVELAND ENGINEERS' CLUB, CITY:

Gentlemen, — Your committee, appointed to consider the clearance height of the overhead bridge on Detroit Street, where the same crosses the N. Y. C. & St. L. R.R., reports as follows:

The plans of the structure and the work as far as it has been completed have been examined, and it was found that the height of 16 ft. 3 in. was established by mutual consent of both parties, the City and the

Railway Company, under Section 333717 D. of Ohio Laws, passed May 2, 1902, which provides that a municipality may compel the separation of grades, where the plans and specifications are reasonable and practicable, and that this height of 16 ft. 3 in. is in the minimum.

The new street grade of 4 per cent. on East approach and 0.6 per cent. on West approach has been established with a minimum damage to abutting property. In order to establish this grade, it was necessary to lower the railway tracks about four feet, which change is possible without causing an unsightly dig in the grade line.

To have made further depression of the tracks would have required several expensive changes of sewers, water and gas mains.

To have raised the structure to a clearance of 21 ft. above the tracks, as now depressed, would add approximately $40 000 to the property damages.

It is to be regretted that a legal height of less than 21 ft. is permissible over any main line of railway track, as such can only be a source of great danger to the employees, who have no recourse to damages.

Therefore, this committee would recommend that legislation be enacted that will raise the minimum to as near 21 ft. as possible.

(Signed) W. B. Hanlon.
J. D. Cox.

Cleveland, Ohio, February 1, 1906.

Mr. W. B. Hanlon,
303 Electric Building, City:

Dear Sir, — I return herewith report of committee appointed by the Civil Engineers' Club of Cleveland, to investigate the clearance of the Detroit Street Bridge over the tracks of the N. Y. C. & St. L. R. R.

While I am heartily in accord with the spirit of the report, I must take exception to the recommendation, that the legislature be petitioned to change the act that now makes 16 ft. 3 in. the minimum clearance, where municipalities are seeking to abolish grade crossings. To go to even a large expense in order to obtain 21 ft. clearance in order to protect lives of train men is certainly justifiable, but there often arise cases, and here in Cleveland they have arisen, where the insisting upon obtaining 21 ft. clearance would probably prevent the abolition of the grade crossings. I believe a clearance of less than 21 ft. is decidedly better than the continuance of a grade crossing.

The changing of the present act which permits a less clearance than 21 ft. under certain conditions would, therefore, seem unwise, and I think we can rest assured that the railway companies will always insist on the maximum clearance, as not only are the lives of their employees in danger but also the freight-carrying capacity would be curtailed by too small a clearance.

Yours truly,

(Signed) Robert H. Hoffman.

Engineers' Club of Minneapolis.

ANNUAL MEETING, JANUARY 22, 1906. — The 185th meeting was called to order after the annual dinner, participated in by about 40 members at the Dayton Tea Rooms, by President Burch, who, after some brief remarks on the good attendance and thanking those present from the sister club in St. Paul, introduced Captain Powell, engineer in charge of the lock and dam work in the river (midway district). He spoke briefly of the progress of his work; of its "locking the two cities together," and pictured a handsome club building to occupy well-kept grounds in the midway district, and to be occupied by the amalgamated clubs of both cities.

O. Claussen, of St. Paul, expressed the hope that the cordial relations that had always existed between the clubs would continue; his club was always glad to coöperate in advancing any and all good works, public or private.

Professor Hoag followed in a few brief remarks, after which Mr. White, city engineer of Superior, gave a short talk on the experience he was having with their sewer system, and some of their engineer problems. The other speakers were: Mr. Annan, of St. Paul; C. A. P. Turner, Prof. J. M. Tate, Minneapolis; and Mr. Winslow, St. Paul. The regular business meeting followed. President's, Secretary's, Treasurer's and Librarian's annual reports were read and placed on file. The election of officers was by ballot and resulted as follows:

President — James B. Gilman.
Vice-President — W. E. Stoopes.
Secretary — O. P. Bailey.
Treasurer — H. A. Rogers.
Librarian — W. W. Redfield.
Representative to the Association of Engineering Societies — E. P. Burch.

Committees appointed were:

Finance Committee — J. M. Tate, C. L. Pillsbury.

Program and Entertainment Committee — H. B. Avery, C. A. P. Turner, Walter S. Pardee.

Auditor — W. W. Redfield.

Montana Society of Engineers.

LEWISTOWN, MONT., JANUARY 13, 1906. — The nineteenth annual meeting of the Montana Society of Engineers was held in Odd Fellows' Hall, at 10 A.M., President E. W. King presiding. The Secretary being absent, Robt. A. McArthur was appointed Secretary *pro tem.* The following members were present: Messrs. Goodale, Carroll, Dunshee, Vail, Christian, Bowman, Craven, Moulthrop, Winchell, Barker, McArthur, Strasburger, McLeod, Burns, Whitten, Klepinger, Draper, King, Thorpe, Kinney, Borgnis and McClean.

The minutes of the December meeting were read and approved. The applications of the following persons for membership were read: Otto F. Wasmandorff, Henry M. Rae, John McGee, Frank F. Goss, Lyman O. Wilson, A. M. Plumb and R. K. Neill. On motion these applications were approved and the Secretary instructed to issue the necessary ballots, to be canvassed at the next meeting of the Society. The Secretary presented the ballots for membership and Tellers Carroll and Goodale reported H. I. Shaw, J. D. Pope and Geo. Miltenberger duly elected. Ballots for the officers of the Society for 1906 were presented and Messrs. Barker and Vail were appointed tellers. The canvass resulted as follows:

President — Bertram H. Dunshee, of Butte.
First Vice-President — Edward C. Kinney, of Bozeman.
Second Vice-President — Archer E. Wheeler, of Great Falls.
Secretary and Librarian — Clinton H. Moore, of Butte.
Treasurer and Member of the Board of Managers of the Association of Engineering Societies — Sam'l Barker, Jr., of Butte.
Trustee — Geo. W. Wilson, of Butte.

President King retired from the chair and President Dunshee was duly installed as President of the Society for the ensuing year. The reports of the Secretary and Treasurer were read and referred to the proper committee.

The Committee on Mining Laws reported progress. A general discussion on the advisability of this Society withdrawing from the Association of Engineering Societies ensued, and on motion the Secretary was instructed to solicit the written opinion of each member of the Society as to whether or not we shall continue the JOURNAL OF THE ENGINEERING ASSOCIATION. Here adjournment until 2 P.M. took place.

The meeting was called to order by President Dunshee. The first order of business was the annual address of E. W. King, the retiring President. Following the address was the thesis on "Steam Turbines," by Prof. C. H. Bowman of the School of Mines, at Butte. This paper was discussed at length and much information gained therefrom. Mr. Edward C. Kinney read a paper on a Kansas power plant, constructed by him some years ago. Prof. Geo. W. Craven of the School of Mines gave an excellent written account of the Madison River power plant. The Secretary read several letters of regret from members of the Society expressive of the writer's non-ability to be present. Messrs. Thorpe, Plumb, Goss and Wasmandorff gave short talks on these subjects: Hydraulic Rams, Ore Roasting, Havre Water Works, Water Power Plant at Lewistown. The Secretary was instructed to extend the thanks of the Society to all parties who had contributed to the success of the annual meeting. A banquet in the evening was mentioned and the meeting then adjourned.

ROBT. A. MCARTHUR, *Secretary pro tem.*

BUTTE, MONT., FEBRUARY 10, 1906. — The regular meeting of the Society for the current month was held at the usual hour in the Society room, No. 225 North Main Street, with President B. H. Dunshee presiding.

On the arrival of a quorum, the following proceedings were had: The minutes of the January meeting were read and approved. The application of Adam Thomas Shurick for membership was read and, after approval, the Secretary was instructed to prepare the necessary ballot, to be canvassed at the next meeting. The ballots of the candidates whose applications were presented at the last meeting were counted and the following persons decided unanimously elected members of the Society: Messrs. Rae, Wasmansdorff, Goss, Plumb, Wilson, Neill and McGee. The Committees on Mining Laws and Library Furniture reported slow progress. The President's annual address and the other papers read at the last annual meeting were ordered sent to the JOURNAL publishers as soon as the Secretary could procure the copies. On motion, all members in arrears for dues for three years were suspended and the information furnished them that reinstatement follows the payment of said dues without further action of the Society. On motion, the following resolution was adopted and the Secretary instructed to send a copy to each member of Montana's congressional delegation.

"*Be it resolved:* The Montana Society of Engineers, believing the Mondell Bill, H. R. 7006, now awaiting congressional action, would, if it should become a law, be of very great benefit to our state educational institutions, would respectfully solicit your favorable consideration and vote in favor of said bill."

The meeting then adjourned.

CLINTON H. MOORE, *Secretary.*

Association of Engineering Societies.

Vol. XXXVI. MARCH, 1906. No. 3.

PROCEEDINGS.

Engineers' Club of St. Louis.

St. Louis, February 21, 1906. — The 611th meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, Wednesday evening, February 21, 1906.

President Layman presided. There were present about forty-five members and sixty-five guests (total 110). The meeting was an open one and the number of ladies present was extremely gratifying.

A vote of thanks was extended to Colonel Ockerson for donating to the library a number of documents pertaining to the Tenth International Congress of Navigation, held in Milan in September, 1905.

The Club voted to have the President of the Club, Mr. Layman, represent the Club at the dinner of the St. Louis Academy of Science in commemoration of its fiftieth anniversary. In case of the absence of the President it was understood that the Vice-President should serve.

Mr. Henry Elliot and Mr. P. A. Morse were elected members of the Club.

Owing to the fact that so many guests were present to hear Colonel Ockerson's talk on "Some Objects of Interest in Europe," the other business matters of the Club were postponed until the next meeting.

After a very delightful illustrated talk by Colonel Ockerson the members and guests adjourned to the reception rooms of the Club where refreshments were served.

R. H. Fernald, *Secretary.*

St. Louis, March 7, 1906. — The 612th meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, Wednesday evening, March 7, 1906, Vice-President Fish presiding in the absence of the President. There were present forty-eight members and six visitors.

The minutes of the 611th meeting were read and approved and the minutes of the 402d and 403d meetings of the Executive Committee were read.

An application for membership was presented from George Percy Cole.

A report was presented by the Committee on Extension of Membership involving several changes in the Constitution and By-Laws. The report recommended the classification of members as active, associate and junior. The report also suggested a reclassification of the present membership after the adoption of the amendments suggested. It was moved by Mr. Rohwer that a copy of this report be furnished each member of the Club and that action be deferred until the next meeting. Motion carried.

Owing to the lateness of the hour on the evening of February 7 it was impossible to discuss the paper presented by Mr. Rohwer at that time. The meeting of February 21 was of such a character that this discussion was postponed until the present meeting. The subject of the paper was "Railroad Construction in the Southwest; or, Meeting with Extremes." The discussion was participated in by Messrs. Robert Moore, Russell, Flad, Van Ornum, Fish, Greensfelder and Rohwer.

The Secretary called attention to the various positions mentioned in the recent circular relating to the Bureau of Information.

The paper of the evening, entitled "Railway Accidents; Their Cause and Cure," was presented by Mr. C. A. Moreno. The paper treated especially of accidents to trains, involving casualties to passengers, which consist chiefly of two classes: namely, collisions and derailments. The writer showed that while the former class is decreasing, the latter has increased to an alarming degree, due almost wholly to defective roadway in its relations to modern equipment and speed of trains. The remedy proposed is governmental supervision of railway construction, which the writer holds is of greater importance than municipal supervision of building construction and which would result in an approximately perfect roadway and the consequent reduction of derailment accidents to a minimum. The interesting discussion was participated in by Messrs. Hanna, Robert Moore, Flad, Russell, Rohwer, Helm, Ockerson, Greensfelder, Adrean and Moreno.

Adjourned.

R. H. Fernald, *Secretary.*

St. Louis, March 21, 1906. — The 613th meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, Wednesday evening, March 21, 1906. President Layman presided. Thirty-eight members and seven visitors were present.

The minutes of the 612th meeting were read and approved. The minutes of the 405th meeting of the Executive Committee were read.

The application of Mr. John Hunter for membership in the Club was read and referred to the Executive Committee.

Mr. George Percy Cole was elected to membership.

The report of the Committee on the Extension of Membership, copies of which had been mailed to each member of the Club, was taken up for action. In order to bring the matter before the meeting the Secretary moved that the report be adopted. Seconded by Mr. Flad. Upon the suggestion of the President, the Secretary changed his motion to cover Section I only, which reads: "The membership of the Club shall be divided into the following classes: Active Members, Honorary Members, Associate Members and Juniors."

After a warm discussion, participated in by about fifteen members, Mr. Wheeler moved to amend the above motion so that Section 1 shall read, "The membership of the Club shall be divided into the following classes: Members, Honorary Members and Juniors." Seconded by Mr. E. C. Parker. The amendment was lost by a vote of twenty-five to two.

After further discussion the motion to adopt Section 1 as read was lost by a vote of nineteen to sixteen.

Mr. H. H. Humphrey then moved that the whole matter be referred back to the committee for revision in the light of the discussion of the evening and that the committee be instructed to report at the next meeting. This motion was amended by Mr. Richard McCulloch so that the committee should be increased to five by the addition of two members who are at present opposed to the report of the committee as it stands.

It was moved by Mr. Wall that the whole proposition be laid on the table. Seconded by Professor Van Ornum. This motion was lost by a vote of twenty to eleven.

Mr. Ockerson moved, as an amendment to Mr. Humphrey's motion, that the report be accepted and filed. This amendment was lost by a vote of eighteen to eight.

Mr. Flad then offered as an amendment that the committee be increased to seven instead of five as suggested by Mr. McCulloch's amendment. This amendment was lost by a vote of sixteen to eight.

Mr. Humphrey's motion with Mr. McCulloch's amendment was next voted upon. The motion was lost by a vote of eighteen to seventeen.

It was then moved by Mr. Flad that further discussion of the entire matter be deferred until the next meeting. This motion was carried unanimously.

Owing to the lateness of the hour it was necessary to postpone the paper of the evening on "Mechanical Draft," by Prof. J. H. Kinealy.

The Secretary announced that Prof. H. B. Shaw, of the University of Missouri, would present a paper on "The Electric Drive," at the next meeting of the Club, to be held April 4, and requested Professor Kinealy to present his paper at the meeting of the Club to be held April 18.

The President of the Club, Mr. Layman, presented a written report as delegate to the fiftieth anniversary celebration of the Academy of Science of St. Louis, held Saturday evening, March 10, at the Mercantile Club. He also transferred to the Club a bronze souvenir medal commemorating this semi-centennial. The following resolutions were adopted by the Club:

Whereas, The Academy of Science of St. Louis marks with the year 1906 the attainment of the fiftieth year of successful and unbroken existence as an organization devoted to the advancement of science: and,

Whereas, By virtue of many interests in common and a long period of intimate relationship, the Engineers' Club entertains a peculiarly cordial attitude toward that organization:

Therefore, be it resolved, That the Engineers' Club of St. Louis extends greetings to the Academy of Science of St. Louis on the attainment of its fiftieth anniversary; that we felicitate it upon its magnificent record of valuable contributions to scientific literature; and that we extend to it as an organization our friendly coöperation and our best wishes for its continued prosperity. May it retain a high standard of excellence in the field of scientific investigation, and by its further good works continue to justify the noble objects and ambitions of its founders.

Further, be it resolved, That the Secretary of this Association communicate these resolutions in writing to the president of the Academy of Science.

Adjourned.

R. H. Fernald, *Secretary.*

April 4, 1906. — The 614th meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, Wednesday evening, April 4, 1906, President Layman presiding. Sixty-seven members and fifteen guests were present.

The minutes of the 613th meeting were read and approved.

The order of business was changed and the paper on "The Electric Drive," by Prof. H. B. Shaw was presented before the regular business of the evening.

The paper was of general interest, and prompted discussion from Messrs. Humphrey, McCulloch, Meston, Borden, Bryan, Langsdorf, Russell and Layman.

After the discussion of the paper the supplementary report of the Committee on Extension of Membership was presented.

In the absence of the chairman, Mr. Zeller, the secretary of the committee, Mr. Bryan, explained the details of the report and pointed out the points of difference between the supplementary and original reports.

Mr. Flad moved that the report of the committee be accepted and the thanks of the Club be extended to the committee for the excellent work it has done. The motion was carried.

Mr. Brenneke moved the adoption of the report in its entirety and also moved that the amendments to the Constitution be sent out to letter ballots. Seconded by many.

After some discussion Mr. Hanna moved as an amendment that each clause be considered separately. This amendment was accepted by Mr. Brenneke. Amendment adopted.

Section 1 of the Constitution aroused considerable discussion, but was finally adopted as read, by a vote of 61 to 3.

Section 2 of the Constitution adopted as read.

Section 3 of the Constitution adopted as read.

Section 4 of the Constitution adopted as read.

Section 5 of the Constitution adopted as read.

Section 6 of the Constitution adopted as read.

It was moved by Mr. Flad that the amendments to the Constitution be adopted as a whole and be sent out for letter ballot. Motion carried.

Adjourned.

R. H. Fernald, *Secretary.*

Civil Engineers' Club of Cleveland.

Semi-Monthly Meeting, February 27, 1906, called to order in the rooms of the Club by the President. Present, fifty members and visitors.

The discussion of General Smith's paper was continued, the President giving a brief outline of the original paper. Mr. B. F. Morse submitted a written contribution to the discussion, which was read by the Secretary.

Messrs. Hoffman, Lehman, Green, Lane, Schowalter and others then took part in the verbal discussion that followed. On motion of Mr. Osborn, a vote of thanks was tendered the non-members who had taken part in the discussion.

Mr. W. J. Carter gave a brief account of the various routes that have been mentioned for the proposed high-level bridge to connect the east and west sides, with his reasons for advocating the location of the bridge on the Franklin-Superior St. route. Discussion was taken part in by Messrs. Ritchie, Morse, Palmer, Lane and others. On motion of Mr. Palmer, the following committee was appointed to investigate the proposed routes and report to the Club the one that, in their opinion, will best meet the necessities of the city: Gen. J. A. Smith, N. P. Rice, F. C. Osborn, Jas. Ritchie and F. F. Prentiss.

Adjourned.

Joe. C. Beardsley, *Secretary.*

Annual Meeting, March 13, 1906, at Chamber of Commerce Club.

The meeting was called to order by the President about 8.30 p.m., after dinner, which was served at 7 p.m. Present, eighty-three members and six visitors. Minutes of regular and semi-monthly meetings in February were read and approved.

The following applications for active membership, approved by the Executive Board, were read: Will K. Monroe, B.S.; Robert Stevens Parsons, C.E.; and William von Wolffradt.

The tellers, Messrs. Howe and Nelson, reported the election of the following officers for the ensuing year:

For President — Dr. Dayton C. Miller.
For Vice-President — Charles H. Wright.
For Secretary — Joseph C. Beardsley.
For Treasurer — Walter M. Allen.
For Librarian — Harry S. Nelson.
For Directors (term expires 1908) — Robert O. Rote, Henry M. Lane.
For Director (term expires 1907) — Henry M. Lucas.

The tellers, Messrs. Rote and Nelles, reported the adoption of the proposed amendment to Article II, Section 6, of the Constitution, as follows:

At the regular meeting of the Executive Board, February 6, 1906, the following amendment was unanimously approved and it was read and referred to letter ballot at the regular meeting of the Club, February 13, 1906: Art. II, Sect. 6, last line, substitute the word "ten" for "six," the section reading as amended:

"Section 6. *Honorary.* — Honorary Members shall be gentlemen of acknowledged preëminence in engineering, architecture or applied science. They shall be subject to neither fees nor assessments. The number of Honorary Members shall be limited to ten."

The tellers, Messrs. Evans and Estep, reported the election to active membership of the following: Charles John Conlin, George Ellis Daniels, Philip A. Geier, Clarence H. Judson, John Christian Streng, John Christian Ulmer.

Printed copies of the financial reports of the Secretary and Treasurer were submitted and the former read the following report as to membership:

MEMBERSHIP SUMMARY.

	Hon.	Retired.	Active.	Asso.	Corresp.	Total.
Membership, March 1, 1905..	6	6	176	14	26	228
Elected..........			43	4	1	48
Transferred:						
(other societies)			2			2
(other classes)..		3			6	9
Total gain.......		3	45	4	7	59
Died............			2			2
Resigned........			3	1	2	6
Canceled.........			1	1		2
Transferred:						
(other classes)..			9			9
Dropped.........			3			3
Total loss........			18	2	2	22
Membership: March 1, 1906..	6	9	203	16	31	265

Mr. H. M. Lane, chairman, Program Committee, submitted the report of his committee for the year, hereto appended.

Mr. C. H. Wright, senior representative of the Club on the House Committee, gave an interesting summary of the work of that body and outlined work that he thought should be taken up for the coming year. He particularly emphasized the necessity of solving the Club rooms problem satisfactorily before our present lease expires (April, 1907) and the desirability of maintaining an adequate reference library. His ideas were embodied in the following resolutions which were unanimously adopted:

Resolved, first, That it is the sense of this meeting that the Club should take active steps to see if quarters, suitable and satisfactory to the majority of the members, cannot be obtained at a lower rental than we are now paying; and, at the same time, the question should be considered as to whether or not it is possible to take some action which will result in the Club eventually owning its own Club house.

Second, That some plan should be devised and carried out systematically, year by year, which will result in our securing and maintaining an up-to-date reference library.

Third, That it is the sense of this meeting that this Club might be a much more important factor in the community than it is at present, if each member would feel that he has a personal responsibility in carrying on the work for which the Club was formed.

The following members gave short talks on the recent progress in their several fields of activity: Mr. James Ritchie, civil engineering; Mr. Charles W. Hopkinson, architecture; Prof. C. H. Benjamin, mechanical engineering; Mr. Robert Hoffman, municipal engineering.

Gen. William Sooy Smith, an honored guest of the Club on this occasion, then gave an interesting and forceful talk on the career of engineering with especial reference to the education and duties of engineers.

The address of the President, which concluded the exercises of the evening, gave a humorous and interesting account of his experiences while on a South American trip early in the past year.

Adjourned.

JOE. C. BEARDSLEY, *Secretary.*

Financial Reports of Secretary and Treasurer for Year Ending February 28, 1906.

Secretary's Report.

PERMANENT FUND.

Balance, March 1, 1905		$1 288.69	
Fees	$225.00		
Interest	56.06	281.06	
Taxes			$11.27
Balance, February 28, 1906			1 558.48
Totai		$1 569.75	$1 569.75

GENERAL FUND.

Balance, March 1, 1905		$23.09	
Dues, Active	$1 867 50		
,, Associate	112.00		
,, Corresponding	135.00		
,, Delinquent ($95.00, 45.00, 25.00)	165.00		
,, 1906	20.00	2 299.50	
Advertising		86.00	$10.35
Books and periodicals			39.45
Commissions			11.90
Entertainment		70.75	487.09
Certificates			9.40
Incidentals			14.10
Journal		9.55	449.38
New quarters, subscription		2.00	2.00
Reporting			19.60
Printing			172.28
Postage			101.45
Stationery			33.87
Associated Tech. Clubs			972.00
Secretary			150.00
Telephone (extra name)			6.34
Balance			11.68
		$2 490.89	$2 490.89

SUMMARY.

March 1, 1905, balance Permanent Fund	$1 288.69	
March 1, 1905, balance General Fund	23.09	
Receipts, Permanent Fund	281.06	
Receipts, General Fund	2 467.80	
Disbursements, Permanent Fund		$11.27
Disbursements, General Fund		2 479.21
February 28, 1906, balance Permanent Fund		1 558.48
February 28, 1906, balance General Fund		11.68
	$4 060.64	$4 060.64

BILLS RECEIVABLE.

From members (dues)	$137.00
From members (note)	53.00
	$190.00

BILLS PAYABLE.

Printing	$19.90
Secretary	50.00
Association Engineering Societies	172.90
	$242.80

JOE. C. BEARDSLEY, *Secretary.*

TREASURER'S REPORT.

Received from former Treasurer, February 28, 1905:		
Permanent Fund	$1 288.69	
General Fund	23.09	
		$1 311.78
Received from Secretary up to February 28, 1906:		
On account Permanent Fund		225.00
On account General Fund		2 463.50
On account Interest Permanent Fund		56.06
Total		$4 056.34
Disbursed General Fund	$2 474.91	
Disbursed Permanent Fund — Taxes	11.27	
		2 486.18
Balance		$1 570.16
Balance on hand, February 28, 1906:		
Permanent Fund		$1 558.48
General Fund		11.68
Total		$1 570.16

Respectfully submitted,

ARTHUR G. MCKEE, *Treasurer.*

ANNUAL REPORT OF THE CHAIRMAN OF THE PROGRAM COMMITTEE OF THE CLEVELAND CIVIL ENGINEERS' CLUB.

During the spring and early fall the Program Committee held several meetings, and the members proposed such a list of good things in the way of program that the chairman has had no difficulty in filling the program for each meeting. We have had eleven meetings or gatherings of the Club during the past year, for nine of which the Program Committee furnished programs or has assisted in providing entertainment.

On May 5 Dr. Richard Moldenke, secretary of the American Foundrymen's Association and chairman of one of the committees of the Society for Testing Materials, described the work of the Society for Testing Materials to the engineers, and pointed out the necessity for such work. The society presented the Club with some of the past transactions, and the Club later voted to become a member of the society and subscribe for the transactions regularly.

On May 23 J. S. Lane, of Akron, Ohio, gave an illustrated lecture entitled, " The Gold and Diamond Fields of South Africa." The meeting was well attended and the members seemed to enjoy the program.

On June 13 Mr. Robert Hoffman and Mr. Walter P. Rice presented the subject of the " Intercepting Sewer System for Cleveland."

The Program Committee had nothing to do with the summer outing, and hence can claim none of the honor for that successful trip.

On September 30 the engineers were the guests of the Conneaut Dock Company. By the courtesy of Mr. A. W. Johnston, general manager of the Nickel Plate, we were tendered the use of a private car to take the members to and from Conneaut. The trip occupied the entire day, and we believe that all who went felt amply repaid.

On October 10 Mr. F. C. Osborn read a paper on " Engineering Ethics and Fees," which provoked considerable discussion.

The meeting of November 14 was arranged for by other officers of the Club, but the Program Committee was very glad indeed to have Mr. Gustavus A. Hyde tell us of his fifty years' experience with the weather, and we were also pleased to have with us Mr. James Kenealey, local observer for the United States Weather Station, Ensign W. L. Varnum of the United States Hydrographic Office and Rev. F. L. Odenbach of St. Ignatius College.

Such meetings as this, at which we can pay our tribute to men who have given a life study to some phase of engineering or other subject of importance in which we are all interested, should certainly be encouraged in the future.

On December 12 Gen. Jared A. Smith was to give a talk on the " Dynamics of Sunlight," but at the last moment had to give it up on account of illness, and hence there was an impromptu discussion on the subject of " Concrete."

On January 9 Mr. N. H. Harrington, of Lansing, Mich., gave a very interesting talk on the " Use of the Suction Gas Producer for Power Purposes," bringing out many points of interest in the use of this style of apparatus, by which far greater efficiency is obtainable than by the ordinary steam boiler and steam engine.

On February 13 Gen. J. A. Smith read an exceedingly interesting paper entitled, " Some Phases of Foundations for Buildings in Cleveland, with Special Reference to the Court House Foundation." As this paper provoked considerable discussion, a special meeting was held on February 27, at which the discussion was continued, and at which Mr. Carter, city engineer, also presented an interesting paper on the High Level Bridge between the business center of Cleveland and the west side.

In conclusion, I wish to thank the members of the Program Committee for their readiness to serve and for the prompt way in which they attended committee meetings when they were called, and also wish to express my gratitude to the members of the Club for the hearty way in which one and all have aided in the work, when they were called upon for suggestions or services. The year's work has certainly been a pleasure, and I can only hope that the next chairman will find as much hearty support.

The object which the Program Committee has attempted to carry out during the previous year has been to bring before the members of the Club subjects of local or special engineering interest and, at the same

time, to intersperse these with a sufficient number of evenings devoted to topics of general interest.

If the chairman of the outgoing committee may make a suggestion for the future guidance of any member who may succeed him, it will be that an attempt be made to divide the subjects discussed as evenly among the different classes of engineers interested, and thus achieve the same ends that would be secured if he had sections devoted to different branches of engineering.

If this broader program is carried out, it will probably be found necessary to hold special meetings almost every month during the fall, winter and spring.

H. M. Lane, *Chairman Program Committee.*

Boston Society of Civil Engineers.

Boston, February 21, 1906. — A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.45 o'clock P.M., President John W. Ellis in the chair; 230 members and visitors present.

The record of the last meeting was read and approved.

Messrs. Henry B. Drowne and Winslow H. Herschel were elected members of the Society.

On motion of the Chairman of the Committee on Excursions, the thanks of the Society were voted to Benj. W. Wells, Fire Commissioner of Boston, and Mr. B. F. Flanders, Superintendent of the Fire Alarm, and his assistants, for courtesies shown members of the Society on the occasion of the visit to the Boston Fire Alarm Station this afternoon.

The literary exercises consisted of a very interesting account by Mr. Frederic P. Stearns of the reports of the Board of Consulting Engineers for the Panama Canal and the general conditions relating to the design and construction of the canal.

The talk was illustrated by numerous lantern slides and a large number of plans and diagrams.

Adjourned. S. E. Tinkham, *Secretary.*

Twenty-fourth Annual Dinner.

The twenty-fourth annual dinner of the Boston Society of Civil Engineers was held at the Hotel Vendome, Boston, Tuesday evening, March 13, 1906, and was attended by 134 members and guests. The usual informal reception was held at six o'clock and the dinner was served at seven o'clock.

The President of the Society, Mr. John W. Ellis, presided and acted as toastmaster. The following members and guests responded with brief speeches: Mr. Frederic P. Stearns, president of the American Society of Civil Engineers; the Hon. George H. Utter, governor of Rhode Island; Mr. Charles F. Prichard, president of the American Gas Light Association; Mr. M. N. Baker, editor of *Engineering News*; Dr. Frederick W. Hamilton, president of Tufts College; Mr. Harrison P. Eddy, chairman of the Sanitary Section of the Society; Prof. George F. Swain, of the Massachusetts Institute of Technology; and Mr. Henry Manley, past president of the Society. Music was furnished by the Albion Quartet.

Sanitary Section.

Boston, Mass., March 7, 1906. — The annual meeting of the Sanitary Section of the Boston Society of Civil Engineers was held Wednesday evening, March 7, 1906, at 7.30 p.m., at the Society rooms, Tremont Temple, Boston, Chairman H. P. Eddy in the chair; 70 members and visitors present.

The report of the Executive Committee was read by the clerk, and on motion of L. M. Hastings was accepted and placed on file.

The report of the Committee on Uniform Sewerage Statistics was read, and on motion of C. W. Sherman it was voted that the report be printed and distributed among the members and that the matter be brought up for discussion at an early meeting of the Section.

The following officers were elected for the ensuing year:

Chairman — Freeman C. Coffin.

Vice-Chairman — Robert S. Weston.

Clerk — William S. Johnson.

Executive Committee — Harrison P. Eddy, Arthur T. Safford, Arthur D. Marble.

The literary exercises of the evening consisted of papers as follows:

" An Account of Several of the Small Sewage Disposal Systems which have been Constructed to Protect the Purity of the Metropolitan Water Supply," by William W. Locke.

" The Sewage Disposal Plant at Vassar College," by Ellen H. Richards.

" The Sewage Disposal Plant at the State Colony for Insane at Gardner," by J. J. Van Valkenburgh.

" The Sewage Disposal Plant at the State Normal School at Hyannis," by George H. Wetherbee, Jr.

All of the papers were illustrated with lantern slides.

William S. Johnson, *Clerk.*

Annual Report of the Executive Committee of the Sanitary Section.

During the year ending March 7, 1906, the Section has enrolled 20 members, 13 of whom were members of the main society. It has lost by death during the same period one member, making the total membership at the present time 167.

During the year six meetings have been held; there has been one excursion and the Section has furnished two papers for one of the regular meetings of the main society.

The attendance at the meetings and the papers presented have been as follows:

March 1, 1905, attendance 38. " Timber Tunneling in Quicksand," by R. K. Porter.

April 5, 1905, attendance 49. " A Winter Visit to Some Sewage Plants in Ohio, Wisconsin and Illinois," by C.-E. A. Winslow.

June 24, 1905, attendance 58. " Excursion to the Sewer Outlets at Deer Island, Nut Island and Moon Island in Boston Harbor.

October 4, 1905, attendance 44. " Breakage in Sewer Conduits; Its Cause, Effect and Prevention," by Alexander Potter.

December 6, 1905, attendance 67. " Sewage Purification at Columbus, Ohio: A Description of the Testing Station, a Synopsis of the

Results Accomplished there and an Outline of the Design of the Proposed Works," by George W. Fuller.

January 24, 1906, attendance 96. A regular meeting of the main society, at which the following papers were furnished by the Section: "An Informal Talk about a Visit, in 1905, to the Percolating Sewage Filters at Birmingham and the Contact Beds at Manchester, England," by L. P. Kinnicutt; "Observations of a Sanitarian in Sicily and Other Parts of Southern Europe," by W. T. Sedgwick.

February 7, 1906, attendance 48. "The Pollution of New York Harbor," by George A. Soper.

The average attendance at the meetings of the Section has been 51. The greatest attendance at any meeting was 67, and the smallest, 38.

All of the papers presented have been, or are to be, printed in the Journal of the Association of Engineering Societies. The Journal during 1905 contained 32 papers, of which 12 were furnished by the Boston Society, and of the 12 furnished by the Boston Society, 5 were presented before the Sanitary Section.

The custom of having a dinner in connection with the meetings has been continued with success, the average attendance at the dinners having been 39.

For the Committee,

William S. Johnson, *Clerk.*

Boston, March 21, 1906. — The annual meeting of the Boston Society of Civil Engineers was held in Chipman Hall, Tremont Temple, at 7.55 o'clock p. m., President John W. Ellis in the chair. Fifty-nine members present. The record of the last meeting was read and approved.

The Secretary read the annual report of the Board of Government, and, on motion, it was accepted and placed on file.

The Treasurer read his annual report, and, on motion, it was accepted and placed on file.

Mr. E. W. Howe, the retiring Treasurer, spoke substantially as follows: "In surrendering the office of treasurer it is due to the Society that I should express my appreciation of the honor conferred upon me, and the confidence shown in continuing me in the office for the past fourteen years. I assure the members that I feel that a great honor has been conferred upon me, an honor which I have done little to merit. I shall always look back upon my fourteen years' connection with the Board of Government with great satisfaction on account of the very pleasant relations with its members.

"In that time there have been on the Board forty-one different members of the Society, and all are members to-day except two, who have passed away; these latter are Mr. Frank L. Fales, a former librarian, who has recently died, and our beloved past president, Albert F. Noyes, who died in 1896.

"The Society has prospered and grown in every way since 1892. At that time the membership was 290; 39 of these have died and 197 are still members, which number is considerably less than one third of our total membership.

"The annual receipts of the current fund for the year preceding my entrance into office were $1 608.68, as against $5 270.77 for the year

just closing. The expenses in 1891–92 were $1 420.68, while for the last year they were $5 706.90, more than four times those of the earlier year.

"The permanent fund transferred to my care by my predecessor amounted to $3 928.78. This has increased to $18 813.33, there having been no loss on any of our investments.

"In 1892 the Society had no rooms, its meetings being held in one of the larger rooms at the American House. The library was stored in a small room at the hotel and was inaccessible to the members except at great inconvenience.

"Congratulating the Society upon its growth and success, which I trust will continue in even greater measure than in the past, and bespeaking for my successor the same kindness and consideration which has been awarded me, I retire to the ranks, thanking all with whom I have been associated for their uniform courtesy and the whole Society for the great honor of its continued choice of me as the custodian of its funds."

On motion of Mr. FitzGerald, the following resolution was unanimously adopted:

Whereas, The Boston Society of Civil Engineers for fourteen years has had the benefit of the patient and able management of the funds of the Society by its Treasurer, Mr. Edward W. Howe, who now feels called upon to resign the office which he has so long and so acceptably filled, be it

Resolved, That we, members of the above Society, desire to place on record our appreciation of the devoted services which Mr. Howe has rendered the Society, and our sincere regret that he is unable longer to fill the office of Treasurer.

The Secretary read his annual report, which was also accepted and placed on file.

Mr. Adams, for the Committee on Excursions, read the report of that committee, which was accepted and placed on file.

Mr. Ferguson read the report of the Committee on the Library, which was accepted and placed on file.

Mr. FitzGerald read the report of the Committee on Quarters, which was accepted and ordered to be printed.

Mr. Howe made a verbal report for the Committee on Advertisements.

On motion of Mr. Adams, the sum of fifty dollars was appropriated for the purchase of standard engineering books.

On motion of Mr. FitzGerald, it was voted to refer to the Board of Government, with full powers, the appointment of the several special committees of the Society.

The Secretary read a memoir of Dean C. Warren, which had been prepared by J. Albert Holmes and DeWitt C. Webb, a committee of the Society.

The President announced the death of William T. Pierce, a member of the Society, which occurred February 26, 1906, and on motion, it was voted that a committee be appointed to prepare a memoir. The President has appointed as that committee Messrs. E. W. Bowditch and D. W. Pratt.

President Ellis then delivered the following address:

"At this time the work for the year, both yours and mine, is at an end, and I wish again to assure you of my appreciation of being permitted to serve you as your President.

"I should be unjust to my own feelings if I did not first express my sense of gratitude and obligation to our Secretary for his courtesy and

diligence in his service to me; and to the other officers of the Society I am also indebted for their respect and hearty coöperation.

"It is *always* easy to accept an office; it is not so easy to fulfill the duties incumbent upon the office; and one of the most difficult tasks is to make an address at the close of one's service. The question is what to talk about and what to say. The statistics of the financial standing of the Society have been presented fully by the Treasurer. The Board of Government has submitted its annual report, informing you of the membership of the Society, and giving a detailed description of everything that has transpired for the past year. The Library and the Excursion committees and the Sanitary Section have reported in full, so that nothing, in repetition or explanation, is either necessary or entertaining. I wish, however, to emphasize the recommendation of the Board of Government to have it more definitely understood that our regular meetings are open to the many students of our varous schools of technology and colleges with technical departments, without the accompanying attendance of a member of the Society. We are exceedingly fortunate in having so many students within the radius of, say, two miles from our headquarters; and in extending this invitation we are aiding the schools and advancing the interests of the students as well as making our Society popular with them; really a mutual aid to us all.

"It would not seem possible that there is now as much engineering work going on in the vicinity of Boston as formerly; but, although the East Boston Tunnel is finished, we have the Washington Street Subway, Charles River Dam in Boston proper, and throughout the state of Massachusetts various grade-crossing schemes in process of construction or contemplated, as those at Haverhill, Attleboro, Lynn and the railroad tunnel in Providence. The Wachusett Dam and its aqueducts are about completed in this state, and there is naturally a gradual migration of engineers to the additional water supply of New York. There surely is sufficient work at the present time to encourage the young engineer; and the vastness and requirements of the new projects keep the consulting engineer thinking and pondering both day and night.

"I have thought it best not to talk very much of the past, trespassing upon your patience with statistics; nor to endeavor to foretell the future, as I might be tempted to prophesy so much that verification would be impossible hereafter. Nothing, then, is left but the present; and although it apparently seems to be a vacant theme, I will endeavor to speak of our profession as it exists to-day, not only in name, but in actual live practice. It is not what has been done, or is to be done, but what we are doing now.

"The means and manner of commissions arriving at the value of water rights and water-works plants, based upon the evidence of expert testimony, which is usually so comprehensive of itself, the two sides varying radically, would be a welcome and instructive topic; but, personally, I should feel that I was doing an injustice to my associates to divulge or to publish the arguments and deductions of a commission of which I have been a member, especially when the statement would be from a minority, without the full consent of the majority. I can say, however, that with all the evidence submitted in a careful and elaborate manner, based partly on experience and practical knowledge and partly on assumption of cost of production less depreciation, with consideration

of present earning capacity, good-will, future value, purity and source of supply if water is for domestic use, regularity and adequacy of supply if for power purposes, etc., the commissioner or referee is obliged to apply his own knowledge with considerable tact and judgment and make many subdivisions of the evidence in order to make an intelligent report. The evidence, however, must be the foundation upon which the report is made, or it will fail to receive the support of the counsel and the desired confirmation by the court. All valuations obtained through a commission are expensive both in money value and time, and whenever possible settlement should be made without resorting to legal adjudication.

" In actual practice the engineer is called upon, not only to design a plan of his own and to have responsible charge of carrying the plan into execution, but also to examine and pass judgment upon the plans and methods of construction of his associates. There is also involved with such examination an opinion of the value of the work or plant for the ultimate purpose of determining either the fair amount of actual payment for the transfer of ownership or the estimated cost of the work. This is the duty of the expert, and all his statements and conclusions, or technically, his opinion, are to be made under oath. The real meaning of what constitutes an expert has been so mixed up by the lawyers, who have clouded it by definitions and declarations based upon sentiment and sarcasm that even common sense has been eliminated; and yet the engineer who has become skillful through practice and experience is *the expert* who commands respect from the lawyer and the court with his practical opinion. The application of honesty, coupled with the principle of ordinary justice, must and should be the foundation of an expert's opinion.

" This thinking that either our eyesight is affected or the focus of our eyeglasses is wrong, so that the figure six has become the figure nine when we want to swell the amount, or the reverse when we want to contract the amount, for the purpose of valuation, is supreme only on the direct examination, and is usually worthless for the final consideration or decree of the court or commission. The expert who verifies his opinion by his experience, by citations from actual practice, by directly answering the cunning quizzing of the experienced practitioner (very often mixed with a hypothetical solution sufficient to make complete deception), and by an exhaustive study of the actual condition of facts relative to the existing conditions of the property involved, will find his services valued and respected by both contending parties. The court or commission wants facts, not theoretical exploitations of the truth based upon arithmetical deductions or formulas made some time in the middle ages. In this connection I am reminded of the words of our deceased past president, Mr. James B. Francis, which at the time was a lesson to me of itself. During the trial of a case, after a witness had completed his evidence, which was very entertaining, full of assumptions, well tabulated and volubly described, the regular noon intermission was taken, and Mr. Francis, on being asked his opinion of the evidence of this witness, replied in his characteristic way: ' A small amount of truth, spread over a great amount of surface.' The practice of the expert tending to criticise the facts as not being what they should be, or what he would have designed or constructed, is embarrassing and very annoying to the court, as it creates a question of unwarranted admission, and allows an objection

to be made, — a vast amount of oratorical discussion, increasing alike the expense of the trial and the volumes of testimony, — entirely valueless and in the end discreditable to the engineer.

"Though the expert engineer from practice and experience is qualified to state his opinion clearly and as he honestly believes the facts to be, he must realize that the law is the regulator of how far and to what extent he can elaborate; he should never attempt to deliver an essay or dissertation to display his particular ability or knowledge, as he will soon be unintentionally instructing the court, provided the lawyers allow this trespass upon their own rights.

"There is another function, besides that of the expert, for an engineer to fill, both naturally and creditably to himself, namely, that of the business man. The engineer, like other human beings, naturally has a mental equipment, and he is a member of a profession which ranks among the highest in the world; from its earliest existence it has continually progressed so that it embraces all the divisions of engineering and takes in the new with the old, as they continue to master Nature's forces, the most recent being the generation of electricity. The engineer is acknowledged to be competent, by the application of the immutable laws underlying his profession, to design and be responsible for the construction of great works, and in doing so he knows the ultimate results to be obtained in the completion of the works; he is primarily the agent for the proper and judicious expenditure of a vast amount of money, to result in the making of colossal fortunes for others. The engineer is capable of directing expenditures for the completed structure or plant, and will so direct or compel the advancement of the several units at the same time that the culmination of the different parts of the project will be simultaneous, without loss of time or payment of interest money, and thus insure a profit-bearing success. From the inception of a usual business undertaking to the time of beginning operations for testing its earning capacity it is strictly an engineering problem; and afterwards during operation questions arise for changes, which must be decided at once and be executed without affecting the operation or earnings of the business. Surely the engineer, being fully acquainted with the details of construction of the plant, and having the discretion, foresight and ability to decide at once whether the changes can be made, can procure the apparatus and constructive material necessary to push the work to completion without unnecessary delay or cost.

"There is too much apathy or silence on the part of the engineer himself in regard to acquiring, receiving or accepting appointments, even of an honorary nature; for such positions are the mere stepping stones to other positions requiring his professional knowledge; and while in the beginning they are only of honor to himself and the profession generally, without compensation, it is through acquaintances formed in these semi-public associations that not only do his talents and value become known and wanted, but he receives appointments with large responsibilities and corresponding compensation. There seems to be a tendency at the present time (and I have thought more particularly so in this locality) to discredit the engineer's fitness to fill positions requiring business activity, and it is the actual fact that recently some of the most prominent commissions where engineering knowledge and experience are a necessary qualification, have been filled by men of legal acquirements only.

"The industries of the country require their affairs to be managed by men of intelligence and executive ability, and who is better qualified than the designer and constructor to manage and direct, or, in fact, to make a success of his own work? Such a person is the engineer; reinforced by a combination of technical knowledge and scientific training, with administrative foresight and executive ability, having more than the average amount of intelligence and force, he will take charge and be successful as the head and brains of our principal industries.

"While the engineer should be one of the foremost leaders in civilization he should also be identified with the social side of life and make progress in mingling with the public, both commercial and political; in fact, broaden out from the technical to the practical, and then become fitted for contact and exchange of opinions with all grades of humanity.

"In conclusion, as an engineer *is* 'a person of genius or ingenuity,' he should be ingenious enough to have his genius recognized, while maintaining his principles of right and justice, so well defined and practiced in his profession that there is never a need of the reminder to 'stand pat' where his integrity and honesty is in question, as the words 'Not for sale' are indelibly inscribed on the escutcheon of every engineer, whether he is in good standing on the rolls of any engineering society, or is practicing his profession either as an expert, or as a business man."

At the conclusion of the address the tellers of election, Messrs. Nathan S. Brock and Franklin M. Miner, submitted the result of the letter ballot, and in accordance with their report the following officers were declared elected:

President — Frank W. Hodgdon.
Vice-President (for two years) — Leonard Metcalf.
Secretary — S. Everett Tinkham.
Treasurer — William S. Johnson.
Librarian — Frank P. McKibben.
Director (for two years) — Charles T. Main.

Before declaring the meeting adjourned, the President presented the President-elect, Mr. Hodgdon, who thanked the Society for the honor conferred upon him, and promised his best efforts to further the interests of the Society for the coming year.

S. E. Tinkham, *Secretary.*

Annual Report of the Board of Government for the Year 1905–1906.

To the Members of the Boston Society of Civil Engineers:

In compliance with the requirements of the constitution, the Board of Government submits its report for the year ending March 21, 1906.

At the last annual meeting the total membership of the Society was 592, of whom 563 were members, 2 honorary members, 12 associates and 15 members of Sanitary Section only.

During the year we have lost 12 members; 6 by resignation, 3 by forfeiture for non-payment of dues, and 3 have died.

There have been added to the Society during the year a total of 41 members, of whom 1 is an associate and 7 are members of the Sanitary Section only.

The present membership of the Society consists of 2 honorary mem-

bers, 13 associates and 606 members, of whom 22 are members of the Sanitary Section only; making the total membership 621.

The record of deaths during the year is, Dean C. Warren, died July 6, 1905; Frank L. Fales, died October 5, 1905; and William T. Pierce, died February 26, 1906.

Ten regular and one special meetings of the Society have been held during the year, and the Twenty-fourth Annual Dinner was given at the Hotel Vendome on March 13, 1906. The average attendance at the regular meetings was 87; the largest being 230, and the smallest 29. The attendance at the annual dinner was 134.

At the regular meetings the following papers have been read:

March 15, 1905. — President Frederick Brooks' address upon "Some Changes in Arithmetic to Decimal Reckoning."

April 17, 1905. — Mr. Harold K. Barrows, "Work of the Hydrographic Branch of the United States Geological Survey in New England, and a Discussion of Methods Used for Estimating Stream Flow." (Illustrated.)

May 17, 1905. — Mr. George G. Shedd, "The Garvins Falls Dam and Canal and Hydro-Electric Plant"; Mr. Edward B. Richardson, "The Hydro-Electric Development at Garvins Falls Dam." (Illustrated.)

June 21, 1905. — Prof. Charles M. Spofford, "The Making of Structural Steel"; Prof. John E. Hill, "The Engineering Building at Brown University." (Illustrated.)

September 20, 1905. — Mr. George W. Blodgett, "Recent Developments in the Old Colony Street Railway System." (Illustrated.)

October 18, 1905. — Capt. William H. Jaques, "The Russian-Japanese War of 1904–5; Its Scope and Meaning." (Illustrated.)

November 15, 1905. — Mr. George B. Francis, "Construction of Water Power on the Chattahoochee River at Atlanta, Ga." (Illustrated.)

December 20, 1905. — Mr. George S. Rice, "Construction of the New York Subway." (Illustrated.)

January 24, 1905. — Prof. L. P. Kinnicutt, "An Informal Talk about a Visit in 1905 to the Percolating Sewage Filters at Birmingham and the Contact Beds at Manchester, England" (Illustrated); Prof. William T. Sedgwick, "Observations of a Sanitarian in Sicily and Other Parts of Southern Europe." (Illustrated.)

February 21, 1906. — Mr. Frederic P. Stearns, "Discussion of the Report of the Board of Consulting Engineers for the Panama Canal." (Illustrated.)

Two informal meetings have been held in the Society's library during the year. The subjects discussed at these meetings have been as follows:

December 18, 1905. — Laurence B. Manley, "Relocation of Underground Pipes and Conduits on Account of the Building of the Subway and Tunnels in Boston." (Illustrated.)

February 14, 1906. — Sanford E. Thompson, "Proportioning of Concrete."

From the report of the Executive Committee of the Sanitary Section it appears that six meetings of the Section have been held, with the average attendance of 51. At all of these meetings interesting papers have been presented which have been printed in the JOURNAL. The Society has paid for rent, for the use of the stereopticon and for reporting these meetings, the sum of $183.50.

The report of the Treasurer shows that our income for the year available for current expenses has not equaled our expenditures by $436.13. The present balance on hand in the current funds is only $20.20 against $456.33 a year ago. In explanation of this deficit, it should be stated that there have been some unusual expenditures this year due to the enlargement of our quarters, and for doing a larger amount of binding for the library than in former years. The amount expended for furniture and repairs exceeds that of last year by $237, and the cost of binding has increased over last year by $46.40; this accounts for $283.40 of the total deficit, leaving $152.73 to be accounted for in some other way. This latter sum, however, is substantially the same as the deficit of a year ago. Of the items of expense which have exceeded that of last year, that of rent will remain about the same for some time in the future, while the other items will continue to increase with, and in proportion to, the growth of the Society. It would seem, therefore, that the only practical method of caring for the deficit is either by increasing the income from advertisements in the JOURNAL, or by reducing our current expenses. The net income from advertisements this year has been $104.50 less than last year.

Under authority of a vote of the Society, passed at the meeting held April 12, 1905, there has been executed with the Tremont Temple Baptist Church, a lease for three years from June, 1905, for the enlarged quarters which the Society now occupies. This lease has been made in accordance with the offer of the management of Tremont Temple, which was given in the report of the minority of the Committee on Quarters, submitted last March. For an increased annual rental of $300 the Society has for its own use an additional room adjoining the one which it formerly had, and the long corridor in front of these rooms has been partitioned off and made available for book shelves and reading purposes. A lease has also been made with the New England Water Works Association for three years, and the New England Association of Gas Engineers and the Hersey Manufacturing Company still continue with us as tenants at will. The changes seem to meet the present needs of the Society, and will probably be sufficient for the period covered by the lease.

The Board of Government believes that the practice begun some years ago of buying standard engineering books for the Society has proved beneficial, and would recommend that the sum of fifty dollars be appropriated for the purchase of such books for the coming year.

It has been suggested that if it were more generally known that persons not members of the Society were always welcome at our meetings when papers are read and discussed, it would increase the usefulness of the Society and tend to strengthen its membership. The Board recommends that members extend a cordial invitation to all whom they think may be interested in subjects discussed at the meetings, to be present whenever they find it convenient, and to assure them that they will always be welcome whether the member extending the invitation be in attendance or not. It is particularly desirable that all students engaged in technical studies at our colleges and institutions and young men just beginning work, be urged to attend our meetings.

For the Board of Government,

JOHN W. ELLIS, *President.*

Abstract of the Treasurer's and the Secretary's Reports for the Year 1905–1906.

CURRENT FUND.

Receipts:

Dues for 1904–1905	$10.00	
Dues for 1905–1906	3 918.00	
Dues for 1906–1907	57.00	
Sales of Journals	3.25	
Rent of rooms	1 000 00	
Advertisements	282.52	
Balance on hand, March 16, 1905	456.33	
		$5 727.10

Expenditures:

Rent	$1 937.50	
Association of Engineering Societies	1 517.61	
Printing, postage and stationery	607.43	
Salaries of Secretary, Librarian and Custodian	550.00	
Furniture and repairs	262.00	
Incidentals	155.65	
Stereopticon	115.00	
Binding	104.00	
Reporting meetings	103.50	
Commission on advertisements	84.40	
Annual dinner	69.80	
Periodicals	51.25	
Lighting	43.38	
Books	34.95	
Clerical work for Librarian	38.88	
Library maintenance	31.55	
		$5 706.90

Balance on hand, March 21, 1906	$20.20
Amount to credit of Current Fund, March 16, 1905	$456.33
Excess of expenditures over receipts	$436.13

PERMANENT FUND.

Receipts:

Thirty-one entrance fees, Society	$310.00	
Seven entrance fees, Sanitary Section	35.00	
Interest on deposits, savings banks	260.05	
Interest on bond	36.00	
Interest, Old Colony Trust Company	25.40	
Subscription to Building Fund	100.00	
Balance on hand, March 16, 1905	750.01	
		$1 516.46

Expenditures:

Dues on shares Merchants' Co-operative Bank	$300.00
Dues on shares Volunteer Co-operative Bank	300.00
Dues on shares Workingmen's Co-operative Bank	300.00

Deposited in Provident Institution for Savings	$47.74	
Deposited in Boston Five Cents Savings Bank	44.52	
Deposited in Eliot Five Cents Savings Bank	42.72	
Deposited in Warren Institution for Savings	42.16	
Deposited in Institution for Savings in Roxbury	41.66	
Deposited in Franklin Savings Bank	41.25	
		$1 160.05
Balance on hand, March 21, 1906		$356.41

PROPERTY BELONGING TO THE PERMANENT FUND, MARCH 21, 1906.

Twenty-five shares Volunteer Co-operative Bank	$4 200.50
Twenty-five shares Workingmen's Co-operative Bank	3 833.48
Twenty-five shares Merchants' Co-operative Bank	2 193.83
Deposit in Provident Institution for Savings	1 400.68
Deposit in Boston Five Cents Savings Bank	1 306.36
Deposit in Eliot Five Cents Savings Bank	1 252.89
Deposit in Warren Institution for Savings	1 236.84
Deposit in Institution for Savings in Roxbury	1 222.17
Deposit in Franklin Savings Bank	1 210.17
One Republican Valley R. R. Bond. No 2 (par value)	600.00
Cash on deposit in Old Colony Trust Company	356.41
	$18 813.33
Amount of fund as per last annual report	17 613.75
Increase during the year	$1 199.58

TOTAL PROPERTY OF THE SOCIETY IN THE POSSESSION OF THE TREASURER.

Permanent Fund	$18 813.33
Current Fund	20.20
Total	$18 833.53
Amount as per last annual report	18 070.08
Increase during the year	$763.45

Report of Committee on Excursions.

Boston, March 21, 1906.

To the Members of the Boston Society of Civil Engineers:

The Committee on Excursions submits herewith its annual report.

Eleven excursions have been made during the year, as follows:

April 12, 1905. — Tunnel under Fort Point channel at Dover Street Bridge. Attendance, 13.

May 27, 1905. — Wachusett Dam and Reservoir, Clinton, Mass. Attendance, 76.

June 24, 1905. — Point Shirley and the sewer outlets at Deer Island. Nut Island and Moon Island, under the auspices of the Sanitary Section, Attendance, 58.

July 22, 1905. — Henderson's Point, Portsmouth Navy Yard. Attendance, 220.

August 12, 1905. — Official test of New Dry Dock, Charlestown. Attendance, 15.

September 20, 1905. — Quincy Point Power Station. Attendance, 9.

October 18, 1905. — Motor Mart at Park Square. Attendance, 45.

November 15, 1905. — New Cambridge Bridge and Charles River Dam. Attendance, 50.

January 24, 1906. — Revere Rubber Company. Attendance, 21.

February 21, 1906. — Central Fire Station. Attendance, 14.

March 21, 1906. — Washington Street Tunnel. Attendance, 105.

Total attendance, 626; average attendance, 57.

Twenty-four pages of the *Bulletin of Engineering Work* have been published during the year. The Committee wishes to thank those who have aided in this work.

There is a cash balance of $35.23 in the hands of the Treasurer.

Respectfully submitted,

EDWARD P. ADAMS, *Chairman*,
WALTER H. NORRIS, *Sec'y and Treas.*,
CLARENCE T. FERNALD,
HERBERT R. STEARNS,
L. LEE STREET,
Committee on Excursions.

REPORT OF THE COMMITTEE ON THE LIBRARY.

To the Members of the Boston Society of Civil Engineers:

The Committee on the Library begs leave to make the following report for 1905–1906:

During the past year the library has been enlarged and completely rearranged. It now seems that the new quarters are adequate for some time to come.

There have been accessioned since the last annual meeting two hundred and eighty-eight (288) bound volumes, which is approximately fifty per cent. more than was accessioned during the preceding year. Of these new accessions thirteen (13) volumes were purchased by the Society.

The number of books taken from the library during the past year is two hundred and twenty-six (226), an average of nineteen (19) per month. The average taken out per month before the rearrangement of the library was sixteen (16). Since the change the average per month has been twenty-one (21).

The Committee wishes to recommend that the practice of purchasing standard engineering books for the library be continued for the coming year.

Respectfully submitted,

FRANK P. MCKIBBEN,
F. I. WINSLOW,
JOHN N. FERGUSON,
H. K. BARROWS,
Committee on the Library.

Report of the Committee on Quarters.

To the Members of the Boston Society of Civil Engineers:

As the Society during the past year has been through an important crisis in connection with its quarters, it seems wise to place on record a brief statement of the movement.

The lease of the present rooms in Tremont Temple expired in June, 1905. These rooms had been the home of the Society for nine years. They consisted of a library, 42 ft. by 17 ft., and an adjoining room, 12½ ft. by 17 ft., this latter leased to a sub-tenant. The meetings of the Society were held in Chipman Hall, seating 350 persons. The New England Water Works Association occupied a portion of the library as a sub-tenant, and for two years the Association of Gas Engineers had also been a sub-tenant.

Owing to a steady growth both in the library and in the membership, the Society, in 1905, was beginning to feel very much cramped for room.

In this dilemma two plans were submitted to the Society by the Committee on Quarters; one contemplated an expansion in its old position by adding more space to the present rooms, and the other involved a radical change to new quarters in a building which the Suffolk Real Estate Trust proposed to erect on Broad Street, between Doane and Central streets. This building was to be named the Engineering Building, and as it was proposed to collect tenants as far as possible who should be engineers or interested in engineering matters, the agents for the proposed building intended to make the offer to the Society an attractive one.

Other schemes were examined by the Committee, who gave much time to the consideration of every matter connected with the whole subject. These two plans, however, were the principal ones before the Society.

Finally, on April 12, 1905, a special meeting of the Society was held to act upon this important question.

At the meeting a majority report, signed by seventeen members and brought before the Society on March 15, was submitted, and also a minority report, signed by two members. The former recommended moving to the new building, and the latter, the enlargement of the old quarters in Tremont Temple.

The Society adopted the minority report, which was strengthened by the fact that many members who had signed the other report abandoned their position at the last moment.

We have now only to consider the plan adopted by the Society, and to describe the way in which it was carried out.

Briefly, the plan involved leasing an additional room adjoining the old rooms, and adding the corridor or hallway in front of the old rooms to the library by building of partitions at the ends of the hall. This work was carried out in June, 1905. The trustees of the building aided the Society in every way in their power, and expended the sum of $350 in adding the corridor to the library, and for this improvement they agreed to ask no additional rent; the only new charge for rent being $300 for the front room. The amount expended by the Society in various ways in connection with the changes in the quarters was $253.70.

The improvements have certainly added very much to the available space for the library and to the comfort of the members, and there seems every prospect that the Society may remain for several years in its present convenient situation. The time will undoubtedly soon arrive when another move will have to be made. For many years the Society has been struggling to secure a position where its growing wants could be met without plunging its treasury into debt. It has pursued a wise policy. It has created a library, enlarged its sphere of influence and accumulated a permanent fund, which is growing steadily. If judiciously managed as in the past, it will not be many years before this fund will have increased to such dimensions that the Society will be justified in securing what may be called, in fact, " Permanent Headquarters."

For the Committee.

Desmond FitzGerald, *Chairman.*

Montana Society of Engineers.

Butte, Mont., March 10, 1906. — The regular meeting of the Society for the current month was held in the Society room at the usual hour, President Dunshee presiding. At the opening of the meeting the following members were present: Adami, Bowman, Barker, Dunshee, Goodale, Klepinger, McArthur, Moore, Putnam and Winchell, A. N. The minutes of the February meeting were read and approved. Thomas A. Shurick, of Diamondville, Wyo., by a canvass of a regular ballot, was found to be unanimously elected to membership in the Society. In the matter of the withdrawal of the Society from the Association of Engineering Societies, the Secretary read nineteen letters from members opposing such action, and one in favor of so doing. On motion, made and carried, it is declared the sense of the members present at this meeting that this Society continues its subscription to the Journal and remain in the Association. The Secretary reported that the President's address and the papers read at annual meeting held at Lewistown, Mont., had been sent to the Society Journal for publication. Dr. F. W. Traphagen, of the Colorado School of Mines, for many years connected with Montana's educational institutions, gave an account of an ingenious method for locating the source of some stolen gold bullion by chemical analysis. He also gave an outline of a prospective trip of the senior class of the Colorado School of Mines as follows: The class, consisting of more than thirty members, will leave Golden, Colo., April 29, visit numerous mines and reduction works in Colorado, thence go to Utah for similar investigations. They expect to arrive in Butte May 5, and remain here twelve days, then go to the Black Hills and reach home the day before graduation. They will travel by special car and be accompanied by several professors of the Mining School. In view of their visit here, the Secretary of this Society was instructed to procure a suitable meeting place for the evening sessions of these students. The Society then adjourned.

Clinton H. Moore, *Secretary.*

ASSOCIATION
OF
ENGINEERING SOCIETIES.

VOL. XXXVI. **APRIL, 1906.** No. 4.

PROCEEDINGS.

Engineers' Club of St. Louis.

ST. LOUIS, APRIL 18, 1906. — The 615th meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, Wednesday evening, April 18, 1906, Vice-President Fish presiding. Twenty-five members and three guests were present.

The minutes of the previous meeting were read and approved.

The application of Mr. F. R. Mott was presented.

Mr. John Hunter was elected a member of the Club.

The Secretary read letters from Colonel Ockerson and from Governor Francis relating to the conferring of a commemorative diploma upon the Engineers' Club of St. Louis for its active interest and coöperation in the Louisiana Purchase Exposition. The Secretary reported that he had been informed that such a diploma had been prepared for the Club.

The report of the Executive Committee upon the result of the letter for the proposed amendments to the Constitution was as follows:

Total vote cast	141
Required to carry the amendments	94
Voted in favor of amendments	130
Voted against amendments	10
Informal	1
	141

The proposed amendments to the By-Laws were considered for action as designated in the notices for this meeting, sent out April 10, 1906.

It was moved that the proposed amendments to the By-Laws be taken up by sections. Motion carried.

Professor Van Ornum moved that Section 2 of the By-Laws be adopted as read. Motion carried.

Mr. Fay moved that Section 7 of the By-Laws be adopted as read. Motion carried.

The paper of the evening, by Prof. J. H. Kinealy, upon "Mechanical Draft" was presented. The paper treated of the advantages and disadvantages of mechanical draft systems and discussed the general details of chimney draft, induced draft and forced draft. It further

dealt with the methods of operating power plants under each of the above-named conditions, together with the probable relative cost of maintenance, operating expense, etc. The paper further treated of the utilization of economizers. The discussion was participated in by Messrs. Bryan, Fish, Fernald, Metzger and Kinealy.

Adjourned.

R. H. Fernald, *Secretary.*

St. Louis, May 2, 1906. — The 616th meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, Wednesday evening, May 2, 1906, Vice-President Fish presiding. Thirty members and thirteen guests were present.

The minutes of the 615th meeting were read and approved. The report of the 406th meeting of the Executive Committee was read.

The Secretary read a letter from Mr. H. A. Hunicke, Corresponding Secretary of the Academy of Science of St. Louis, thanking the Club for its resolution of congratulation at the time of the fiftieth anniversary of the founding of the Academy.

The application of Mr. Robert L. Lund for membership was read and referred to the Executive Committee.

At this point Mr. Fish yielded the chair to President Layman, who had in the meantime arrived.

Mr. P. M. Bruner then presented the paper of the evening on "Reinforced Concrete Residences." Mr. Bruner described a residence of this type recently erected by the P. M. Bruner Granitoid Company in St. Louis. Numerous photographs, showing the house in the different stages of construction were exhibited, together with sectional and detail drawings of parts of the structure.

The discussion was participated in by Messrs Van Ornum, Fish, McCulloch, Beebe, Layman, Toensfeldt, Holman, Bary and Lindau, and covered such points as the relative costs of concrete and brick or stone construction, porosity of concrete walls, finished appearance and systems of reinforcement in general.

It was announced that the paper for the next meeting would be on "Recent Developments in Electric Railroading," by A. S. Langsdorf.

Adjourned.

A. S. Langsdorf, *Secretary pro tem.*

Civil Engineers' Club of Cleveland.

Regular Meeting, April 10, 1906, at the Club rooms, called to order by the President at 8.15 p.m. Present, thirty-six members and nine visitors.

In the absence of the Secretary, Mr. Lane was elected Acting Secretary.

Minutes of preceding meeting read and approved.

The application of Mr. John Gammell for associate membership was read. The Secretary announced that the President had appointed the following committee to investigate and report upon the subject of new club rooms, the lease on the present quarters and the agreement with the other clubs expiring on April 1, 1907: Cox, Wright, Allen, Neff and

Beardsley; also that the following members had been added to the Water Pollution Committee: Robert Hoffman, George T. Nelles and Charles A. Cadwell. The President announced the Standing Committees for the ensuing year.

The tellers reported the election to active membership of Will K. Monroe, Robert S. Parsons and William von Wolffradt.

The paper of the evening was read by Mr. F. C. Osborn and was an account of his recent trip to South America.

Adjourned.

H. M. Lane, *Acting Secretary.*

Regular Meeting, May 8, 1906, at the Club rooms, called to order by the Vice-President at 8.15 p.m.; present, forty members and visitors.

Minutes of preceding meeting read and approved.

Applications for active membership of Henry P. Brack, Sidney W. Brainard and Arthur E. Peters, approved by the Executive Board, were read.

The tellers, Messrs. Schowalter and Cadwell, reported the election to associate membership of John Gammell.

A communication from the secretary of the House Committee was read, requesting to know the wishes of the Club relative to continuing the present arrangement as to association of the clubs for club room purposes; as to the retention of the present quarters; and as to the annual outing of the clubs. The appointment of the club's Committee on New Quarters was considered to have answered that part of the communication and on motion of Mr. Lane it was voted to endorse the proposition to have an outing, favorably.

Mr. Hanlon, chairman of the Grade Crossing Committee, read two communications relative to clearance, and on motion of Mr. Evans, they were ordered received and filed.

The following resolution of the Secretary was unanimously adopted:

" Believing that Mr. F. S. Barnum is unusually well qualified by education, experience and high personal character for the position of Superintendent of Construction of the new county buildings, it is hereby

" *Resolved,* That the Civil Engineers' Club of Cleveland unqualifiedly endorse and urge his appointment to that position; and that the Secretary be directed to transmit a copy of this resolution to the County Buildings Commission."

The paper of the evening, " Road Legislation and Construction in Massachusetts," was then read by Mr. Asa Goddard, secretary of the Automobile Club.

Adjourned. Joe. C. Beardsley, *Secretary.*

Detroit Engineering Society.

Detroit, April 27, 1906. — At the twelfth annual meeting of the Detroit Engineering Society, held April 27, 1906, in the Employers Association Hall, Stevens Building, the following officers were elected for the ensuing year:

President — Benj. Douglas.

1st Vice-President — W. R. Kales.

2d Vice-President — E. S. Wheeler.

Secretary and Treasurer — Clarence W. Hubbell (reëlected).

The annual meeting was followed by the twelfth annual banquet, at which ninety-eight members were present.

SECRETARY-TREASURER'S REPORT.

MEMBERS.

Members, May 5, 1905		156
Added during year	45	
Resigned during year	11	
Suspended during year	2	
Net gain		32
Total members, April 27, 1906		188

CASH ACCOUNT.

Receipts.

Cash on hand, May 5, 1906	$56.91
Dues collected during year	887.50
From sale of excursion tickets	120.00
Total received	$1,064.41

Expenditures.

Banquet	$188.55
JOURNAL	401.25
Excursion	200.83
Secretary's salary	100.00
Printing, postage and supplies	80.28
Cash on hand, April 27, 1906	93.50
Total	$1,064.41

CLARENCE W. HUBBELL, *Secretary.*

Montana Society of Engineers.

BUTTE, MONT., APRIL 14, 1906. — The regular meeting of the Society for April was called to order at the usual hour by President B. H. Dunshee on the arrival of a quorum. The minutes of the last meeting were approved as read. The Committee on Library Shelving reported that the needs of the Society would be met at an early date. The Society read a request from the Engineers' Club of Philadelphia desiring an exchange of library and society room privileges for visiting members of the Engineers' Club to this city. On motion, such an exchange was approved. A letter from President Leonard, of the School of Mines, and Prof. A. N. Winchell, secretary of the National Association of State Mining Schools, having for its object securing speedy action in Congress on the Mondell Bill No. 7006, was read, and the Secretary was instructed to write Speaker Joseph Cannon requesting his good offices in the matter. The Secretary was instructed to invite the senior class of the State School of Mines to attend the next meeting of this Society, also request ex-President King to do likewise. After some discussion, having for its subject, "The Expected Visit of the Senior Class of Colorado School of Mines to this City," the Society adjourned.

CLINTON H. MOORE, *Secretary.*

Association of Engineering Societies.

Vol. XXXVI. | MAY, 1906. | No. 5.

PROCEEDINGS.

Boston Society of Civil Engineers.

Boston, April 18, 1906. — A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 8 o'clock p.m., President Frank W. Hodgdon in the chair; seventy-two members and visitors present.

The record of the last meeting was read and approved.

Messrs. Barzillai A. Rich and John C. Whitney were elected members of the Society.

The Secretary reported for the Board of Government the appointment of the following committees:

Committee on Excursions: L. Lee Street, C. T. Fernald, J. O. De Wolf, E. M. Blake and E. E. Pettee.

Committee on the Library: F. P. McKibben, F. I. Winslow, H. K. Barrows, F. B. Sanborn and H. J. Hughes.

Committee on Quarters: Desmond FitzGerald, E. W. Howe, G. A. Kimball, F. C. Coffin and F. W. Dean.

Members of the Board of Managers, Association of Engineering Societies: S. E. Tinkham, *ex officio*, J. R. Freeman, Henry Manley, Dexter Brackett, Dwight Porter and C. W. Sherman.

Mr. Hiram A. Miller was then introduced and spoke on "The General Features of the Charles River Basin and Dam," and gave a brief review of the construction work to date. The talk was illustrated with lantern slides. In the discussion which followed, Messrs. FitzGerald, Rollins and Miller took part.

Adjourned.

S. E. Tinkham, *Secretary*.

Boston, May 16, 1906. — A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 7.50 o'clock p.m., President F. W. Hodgdon in the chair; ninety-eight members and visitors present.

The record of the last meeting was read and approved.

Messrs. Harold S. Boardman, Horace P. Hamlin and William E. Mott were elected members of the Society.

The Secretary read a communication from the Secretary of the American Water Works Association extending an invitation to the members of this Society to attend the annual convention of the Association to be held in Boston July 10–14, 1906. On motion of Mr. Coffin, it was voted to accept the invitation, and the Secretary was directed to express the appreciation of the Society for the honor conveyed. The Board of Government was authorized to extend to the Water Works Association such courtesies as seemed to it best.

The Secretary reported for the Board of Government that it had appointed the following as the members of the Committee on Advertisements: The Treasurer and the Secretary of the Society and Mr. F. A. Barbour.

Prof. Lewis J. Johnson then gave an informal account of some "Recent Tests of Reinforced Concrete Beams," illustrated by lantern slides. A discussion followed in which Professors Swain and McKibben and Messrs. Wason, Larned, Thompson and others of the Society took part. Mr. H. W. Telford, of the Engineering Department of Harvard University, supplemented Professor Johnson's account of the tests made in the laboratory of the university on concrete beams, and Professor McKibben spoke particularly of tests made at the Massachusetts Institute of Technology on the shearing strength of concrete cylinders.

Adjourned.

S. E. Tinkham, *Secretary.*

Sanitary Section.

A regular meeting of the Sanitary Section of the Boston Society of Civil Engineers was held at the Point Shirley Club, Winthrop, Mass., Saturday, June 9, 1906.

Horace H. Chase, of Boston, was elected a member of the Section.

The form of Uniform Sewerage Statistics, recommended by a special committee at the March meeting and considered at a special meeting of the Section April 11, 1906, was adopted. It was voted that the printing and distribution of the blank forms be left to the Executive Committee.

Mr. William F. Morse read a paper upon "Modern Methods of Garbage Disposal," which was discussed by the members present.

Previous to the meeting the members visited the plants of the City Refuse Utilization Company on Atlantic Avenue and of the New England Sanitary Product Company on Spectacle Island and enjoyed a sail around the harbor.

Forty-one members and guests attended the meeting and excursion.

W. S. Johnson, *Clerk.*

55

Association

of

Engineering Societies.

Vol. XXXVI. **JUNE, 1906.** No. 6.

PROCEEDINGS.

Boston Society of Civil Engineers.

Boston, Mass., June 20, 1906.— A regular meeting of the Boston Society of Civil Engineers was held at Chipman Hall, Tremont Temple, at 8 o'clock p.m., President Frank W. Hodgdon in the chair; twenty-eight members and visitors present.

The record of the last meeting was read and approved.

Messrs. William T. Blunt, Bertram W. Ransom and John W. Storrs were elected members of the Society.

The Secretary read a memoir of William T. Pierce, a member of the Society, which had been prepared by Ernest W. Bowditch and Daniel W. Pratt, a committee of the Society.

The Secretary announced the death of the following members of the Society: John J. Howard, died May 18, 1906; Isaac K. Harris, died May 21, 1906; and E. Elbert Young, died June 1, 1906. On motion, the President was requested to appoint committees to prepare memoirs of the deceased members.

The President has appointed the following committees: On memoir of John J. Howard, Mr. H. V. Macksey; on memoir of Isaac K. Harris, Mr. Otis F. Clapp and E. F. Dwelley; and on memoir of E. Elbert Young, Mr. H. A. Carson.

Prof. F. B. Sanborn read the paper of the evening, entitled, "Fires and their Prevention in Factories." The paper was fully illustrated by lantern slides.

Mr. S. G. Walker, insurance engineer for Manufacturers' Mutual Fire Insurance Company of Providence, gave a very interesting account of the work of that company.

Adjourned.

S. E. Tinkham, *Secretary.*

[illegible]

[illegible]